00033515

THE
ASIATIC SOCIETY OF BOMBAY
TOWN HALL, BOMBAY-400 023.

Digitized with financial assistance from the
Government of Maharashtra
on 25 June, 2016

ELEMENTS OF CHEMISTRY,

AND

NATURAL HISTORY,

TO WHICH IS PREFIXED

THE PHILOSOPHY OF CHEMISTRY.

BY A. F. FOURCROY.

TRANSLATED FROM THE FOURTH AND LAST EDITION OF THE ORIGINAL FRENCH WORK,

BY R. HERON.

IN FOUR VOLUMES.

VOL. III.

LONDON:

PRINTED FOR J. MURRAY AND S. HIGHLEY, NO. 32, FLEET STREET; J. CUTHELL, MIDDLE ROW, HOLBORN; AND C. MUDIE AND SON, EDINBURGH.

1796.

33515

00033515

CONTENTS

OF

VOLUME THIRD.

CHAP. XVIII. *Iron*, Page 1
XIX. *Copper*, 84
XX. *Silver*, 112
XXI. *Gold*, 137
XXII. *Platina*, 161
XXIII. *Bitumens in general*, 182
XXIV. *Amber and its acid*, 187
XXV. *Asphaltus*, 197
XXVI. *Jet*, 200
XXVII. *Pitcoal*, 202
XXVIII. *Petroleum*, 208

PART III.

The Vegetable Kingdom, 212

CHAP. I. *The structure of vegetables.* ib.
II. *Natural philosophy of vegetables*, 218
III. *Juices and extracts.* 226
IV. *The essential salts of vegetables, and of those in particular which are analogous to mineral salts*, 233

CHAP.

CHAP. V. *The second genus of essential salts, or the pure acids of vegetables,* Page 237

§ 1. *The citric acid,* ib.

2. *The gallic acid,* 242

3. *The malic acid, or the acid of apples,* 247

4. *The benzoic acid.* 249

VI. *Vegetable acids, partly saturated with potash, and of the same acids pure,* 255

§ 1. *The tartareous acidulum, or tartar, and of the pure tartareous acid,* ib.

2. *The oxalic acidulum, or common salt of sorrel, and of the pure oxalic acid,* 276

VII. *Vegetable acids formed by the action of fire, and by the nitric acid,* 288

§ 1. *The pyro-tartareous acid,* 289

2. *The pyro-mucous acid,* 292

3. *The pyro-ligneous acid,* 294

4. *Vegetable acids formed by the nitric acid,* 296

VIII. *Saccharine matter, gums, and mucilages,* 300

IX. *Oils of a fixed nature, that are extracted by expression,* 308

X. *Volatile oils,* 318

XI. *The camphorate principle,* 322

XII. *The spiritus rector, or the aromatic principle of plants,* 327

XIII. *Resinous inflammable juices in general, and of balsams in particular,* 334

XIV. *Resins,* 338

XV. *Gum resins,* 344

CHA

CHAP. XVI. *The pure fæcula of vegetables,* Page 353
XVII. *The farina of wheat, and of ſtarch,* 359
§ 1. *The glutinous part of wheat,* 361
2. *The ſtarch of wheat,* 365
3. *The extractive mucilaginous part of the farina,* 366
XVIII. *Vegetable colouring matters, and their application to the art of dyeing,* 368
XIX. *The analyſis of plants by naked fire,* 376
XX. *Vegetable coal, or charcoal,* 384
XXI. *The fixed ſalts, and earths of vegetables,* 392
XXII. *Fermentations in general, and of the ſpirituous fermentation in particular,* 398
XXIII. *Alcohol, or the product of ſpirituous fermentation,* 409
XXIV. *Acetous fermentation, and of the acetous and the acetic acids,* 434
XXV. *The putrid fermentation of vegetables,* 453

PART IV.

The Animal Kingdom, 458

CHAP. I. *The chemical analyſis of animal ſubſtances in general,* ib.
II. *Blood,* 467
III. *Milk,* 480

ELEMENTS

OF

NATURAL HISTORY

AND

CHEMISTRY.

PART III.

CHAP. XVIII.

Of Iron.

IRON, to which the alchemiſts gave the name of *Mars*, is an imperfect metal, of a livid white colour, inclining to grey, and diſpoſed in ſmall facets. It is ſuſceptible of a very fine poliſh, and may be made very brilliant. It is ſo hard and elaſtic, as to be capable of deſtroying the aggregation of any other metal.

Iron emits a ſmell, eſpecially when it is rubbed or heated. It has likewiſe a very ſtrong ſtiptic taſte, which acts powerfully on the animal œconomy.

Iron is, next after tin, the lighteſt of all metallic ſubſtances. A cubic foot of forged iron weighs five hundred and eighty pounds. It may be hammered into plates; but being very hard, and liable to become much harder under the hammer, it cannot be beat into leaves. Its ductility, when drawn into wire, is much more conſiderable: it is drawn into very fine threads, which are uſed as ſtrings to harpſichord keys. This property appears to depend on its tenacity. Iron is in fact the moſt tenacious of all metals, next after gold. A thread of iron one tenth of an inch in diameter is ſufficient to ſupport, without breaking, the weight of four hundred and fifty pounds.

Pure iron has a peculiar cryſtaline form. In furnaces in which iron has been ſlowly cooled, there are found quadrangular pyramids articulated and branched, and conſiſting of octohædrons inſerted one into another. We owe this obſervation to M. Grignon, maſter of the forges at Bayard in Champagne. Laſtly, beſide all the properties which iron poſſeſſes in common with other metallic ſubſtances, this metal exhibits three properties which are entirely peculiar to itſelf. One of theſe is magnetiſm, or the property of being liable to be attracted by the loadſtone, and of acquiring the virtues of the loadſtone, either when it has remained long in an elevated ſituation; or in a direction between north and ſouth; or when it has been employed as a conductor to the electric fire of thunder, as is evinced by a variety of facts; or when two pieces of iron are ſmartly rubbed one upon another. The ſecond of the ſingular properties of iron, is that of taking fire, and melting ſuddenly when ſtruck with a flint; a phænomenon to which the

poets

poets unanimouſly aſcribe the firſt diſcovery of fire. The third property by which it is diſtinguiſhed, is that of being found with manganeſe in plants and animals; ſome of whoſe juices derive from it their colour: it is even probable that thoſe organic beings themſelves form the metal; for plants growing in pure water contain iron, which may be obtained from their aſhes.

Iron is a metal which abounds very much in nature; for, independently of what plants and animals contain, it is found in almoſt all coloured ſtones, in bitumens, and in moſt metallic ores. But here we are to treat only of ſuch mineral matters as contain a great deal of iron, and are wrought for the purpoſe of extracting the metal from them. In theſe ores, which are very numerous, iron exiſts either in a metallic ſtate, or in the ſtate of an oxide, or mineralized by different ſubſtances.

1. Native iron is diſtinguiſhed by its colour and malleability. It is very rare, and is only found accidentally in iron ores. Margraf found it in a fibrous form at Eibenſtock in Saxony: Dr Pallas has diſcovered, in Siberia, a maſs amounting to 1600 pounds; and M. Adanſon aſſerts, that it is common in Senegal. Some mineralogiſts think that thoſe ſpecimens of native iron are products of art, and have been on different occaſions buried under ground.

2. Ores of black iron, taken in general, ſeem all to belong to an oxide of black iron, more or leſs pure.

Black iron is diſtinguiſhable by its colour, by its property of being more or leſs ſuſceptible of attraction by the loadſtone, and by being altogether inſoluble in acids. This iron is ſometimes cryſtalized in the ſhape of polyhædrons, or round plates, and preſents different

ſhades of the moſt brilliant changing colours; ſuch is that from the iſland of Elba. It there forms a conſiderable mountain, which is wrought above ground. The ore from Sweden is likewiſe a black iron, but not cryſtallized; it conſiſts of maſſes, more or leſs ſolid, mixed with quartz, ſpar, aſbeſtos, &c. It is frequently ſo hard, as to admit of a poliſh, and its ſurface appears like a mirror. Thus it, as well as the former, has obtained the name of *ſpecular iron:* it is found united in conſiderable quarries. This iron varies in the degree of its colour: ſome is perfectly black, which is highly ſuſceptible of attraction by the loadſtone; ſome bluiſh, which is leſs ſo; and ſome grey, which poſſeſſes this property in a very ſmall degree. The iron of Norway is likewiſe a black iron; but it is generally in ſmall ſcales, like mica, often mixed with garnets and with ſhorls. Black iron is ſometimes found in grains. It is likewiſe cryſtallized in cubes; which has made ſome naturaliſts give it the name of *galena* of *iron*, or *eiſen-glanz*. When micaceous iron ore is of a black colour, it is called *eiſen-man*; eſpecially if the ſcales be very large. When theſe ſcales are red, and covered with duſt of the ſame colour, it gets the name of *eiſen-ram*. The ſpecies of iron ore in black octohædral cryſtals very regular and diſperſed in a kind of ſchiſtus, or hard ſteatite, which comes from Sweden, Corſica, &c. ſeems to belong to this claſs of iron ores. It is attracted by the loadſtone, and very brittle. The lamellated brilliant iron of Framont belongs alſo to this ſpecies.

Though the ſeveral ſpecies of black iron ores, which I have joined together in this article, ſeem to bear an evident analogy with one another, ſeveral mineralogiſts have regarded them as very different, and have arranged

them ſeparately. This variety of opinions originates from our not yet having ſufficient knowledge of their nature. It ſhould ſeem, that of theſe ores ſome approach nearer to the metallic ſtate, as the octohædral iron of Corſica and Sweden, which M. Monge compares to martial ethiops. This ſpecies is ſtrongly attracted; others, on the contrary, approach nearer to the ſtate of oxides, as the iron of the iſland of Elba, and particularly the *eiſen-mian*, and *eiſen-ram*, which are not liable to be attracted by the loadſtone. The ores of the iſland of Elba appear to be only black oxides of iron produced from carbonate of iron reduced by means of fire. In this way M. Vauquelin has imitated them with great ſucceſs. To this account of black irons, I ſhall here ſubjoin ſome obſervations made by the Abbe Haüy, of the academy of ſciences. He diſtinguiſhes two primitive ſhapes of theſe irons, which, according to him, announce two ferruginous ſubſtances of different natures.

One is a regular octohædron. To this belongs the iron of Corſica. The cryſtals of this ſpecies are ſtrongly attracted by the magnetic bar. The ſpecular iron ore from the golden mountain, in octohædral ſegments, is a variety of this ſpecies.

The other is the ſhape of a cube. To this laſt belongs particularly the iron ore of the iſland of Elba, of which there are two principal varieties, namely, 1. iron in rhomboids, very obtuſe; 2. iron with ſix pentagons, and eighteen triangles. Theſe varieties are but feebly attracted by the magnetic bar. By filing, M. Haüy obtained from them a reddiſh unctuous powder, ſimilar to that of red micaceous iron, or the eiſen-ram of the Germans.

3.

3. Iron is very often in the ſtate of ruſt, more or leſs oxidated. It then forms ochraceous iron ores. All earths coloured brown or red are of this kind.

4. We muſt beware of confounding with ochres thoſe iron ores which are called *bog ores*. They do, indeed, contain oxidated iron; but that oxide is combined with carbonic acid, and with phoſphoric acid, which appears to have been produced by the decompoſition of vegetables. Bog irons are diſtinguiſhed into rich and poor, fuſible and dry. The rich is only iron a little ruſted, and contains but a very ſmall proportion of earth. Fuſible iron melts very eaſily, and affords caſt iron of a good quality; the metal being in it united only to ſome ſtones which eaſily melt. Dry iron is more calcined, and mixed with ſome very refractory ſubſtances. All bog iron, in general, is uſually arranged in layers, like ſtones, and appears evidently to have been depoſited by water. It is often in the form of pebbles, or flat irregular ſpherical bodies. Organic matters, ſuch as wood, leaves, barks, ſhells, are not unfrequently met with in the ſtate of bog iron. This kind of tranſmutation ſeems to ſuggeſt the idea, that there is ſome analogy between iron and organic bodies. A portion of phoſphate of iron, contained in theſe, which abound more than any other iron ores, communicates to this metal the property of being brittle when cold. Bergman, who was acquainted with iron in this ſtate, but did not determine its nature, called this phoſphate of iron *ſiderites*; ſome German chemiſts have ſince called it *water iron*. We will afterwards explain how this ſalt may be ſeparated from iron that is brittle when cold.

5. The eagle ſtone, or *ætites*, is a variety of bog iron.

Eagle

Eagle ſtones are bodies of various forms, commonly oval or polygonous, conſiſting of concentric layers, diſpoſed around a nucleus, which is often moveable in the centre of the ſtone. The drying and contraction of theſe layers has formed a cavity in the middle, in which ſome fragments of various ſizes float at liberty. This ſtone has received its name from an opinion, that eagles put it into their neſts, and that it helps them to lay their eggs more eaſily, and promotes the effects of incubation. It has been hence inferred, that this ſtone would act powerfully on the fœtus in the mother's womb. Some authors go ſo far as to aſſert, that the pains of a lying-in woman may be brought ſooner on by binding an eagle ſtone to her thigh, and kept back by binding it to her arm.

6. The *hæmatites* is a kind of bog iron, which appears to be formed in the ſame manner as ſtalactites. It derives its name from its colour, which is commonly red like blood, though ſubject to varieties. The hæmatites uſually conſiſts of layers covering one another, and compoſed of convergent needles. The ſuperficies of this ore is covered over with tubercles. Hæmatites are diverſified, not only by colour, but by form too. There is, for inſtance, the needled hæmatites, the hæmatites in bunches of grapes, or *hæmatites botrytis*, &c These ores are pretty often found with muddy iron; and are depoſited on a great many different bodies.

7. The *loadſtone* is nothing elſe but an ochraceous iron ore, very hard and very refractory; which, however, ſome perſons think not very remote from the metallic ſtate. It is known by its property of attracting filings of ſteel. It is found in Auvergne, and in Biſcay in Spain. It is diſtinguiſhed by the diverſities of its colour into ſeveral varieties.

8.

8. *Emery, ſmyris*, is a grey or reddiſh iron ore, conſidered by a number of mineralogiſts as a kind of hæmatites. It is very hard and refractory: great plenty of it is found in the iſles of Jerſey and Guernſey. It is ground in mills into a powder, and uſed in this form for poliſhing glaſs and metals.

9. *Sparry iron* is an oxide of iron in combination with carbonic acid, and tranſported by water. It is uſually of a white colour; but there are ſpecimens of this ore ſtained with almoſt every different colour, grey, yellow, red. It is always in plates of various ſizes, and ſemi-tranſparent like ſpar. It is of conſiderable gravity, and is often regularly cryſtallized: it is found in conſiderable quarries, often mixed with pyrites, as for inſtance at Allevard in Dauphiny; ſometimes it is mixed with grey ſilver ore, as the iron of Baigorry; and ſometimes with manganeſe, as that of Styria. Some chemiſts think it to be a ſpar in which the metallic oxide has been depoſited. Sparry iron is decompoſed by itſelf in cloſe veſſels; and it then yields carbonic acid. What remains is a brilliant black iron, ſubject, in a high degree, to the attraction of the loadſtone, and which may be eaſily melted by the action of a ſtrong fire. The manganeſe which it frequently contains, renders it liable to be altered by the action of air, and makes it take a brown colour, as it loſes its form and conſiſtency.

10. Nature likewiſe preſents us with iron in a ſaline ſtate, combined with the ſulphuric acid, and forming ſulphate of iron, or green copperas. This ſalt is found in the galleries of iron mines, eſpecially in ſuch as contain *pyrites*. It is ſometimes found in green cryſtals, or in the form of beautiful ſtalactites: on other occaſions, again

again, it is not ſo pure, but appears to have ſuffered ſome alteration. If it has loſt only the water of its cryſtallization, it is of a white or a greyiſh colour: it is then called *ſori*. When ſomewhat more thoroughly calcined, it is yellow, and is called *miſſy*. If the calcination has been carried ſo far as to drive off a conſiderable part of the acid, the ſulphate of iron is then red, and bears the name of natural *colcothar*, or *chalcite*; when mixed with inflammable matters, this ſalt is called *melanteri*, from its black colour. All theſe matters have received the common name of *atramentarious* ſtones, as being, no leſs than ſulphate of iron, proper materials for making ink.

11. Iron is often found in combination with ſulphur; it then forms *martial pyrites*. This ore has received the name of pyrites, becauſe it is hard enough to afford a great abundance of ſparks when ſtruck with ſteel. We call this combination native ſulphur of iron. Martial pyrites are commonly in ſmall round maſſes, which are ſometimes regular. They are moſt generally ſpherical, cubic, or duodecahædral. Their form is ſubject to many varieties; a fact which the reader of Henckel's Pyritology cannot fail to be convinced of.

The abbe Haüy, who has paid much attention to the ſtructure of ferruginous *pyrites*, has diſcovered the following principal varieties in their ſhape.

1. The *ſmooth cube*: this is the primitive form of this mineral.

2. *Pyrites* in regular octahædrons.

3. *Pyrites* in cubo-octahædrons: this is the cube with truncated angles.

4. *Duodecahedral pyrites* with pentagonal ſides.

5. *Cubical pyrites* ſtriated on three ſides.

11.

He has ſhown that the cube, whoſe ſtriæ ſo much embarraſſed Stenou and Mairan, by the diverſity of their directions, was nothing but a modification produced by a haſty cryſtallization of the duodecahædron, with pentagonal ſides.

6. *Pyrites* with twenty triangular faces, eight of which are equilateral, and twelve iſoſecles.

7. *Pyrites* with thirty-ſix triangular iſoſceles faces twelve of which are broader and longer than the other twenty-four.

8. *Globular pyrites* ſet with octahædral points; this ſeems to be of a different nature from the preceding.

Some pyrites are externally brown and iron coloured; the greater part are yellowiſh, and even at the ſurface pretty much like copper ores. They are all yellow, and of a copper appearance within; and they conſiſt moſtly of needles, or pyramids of a number of ſides, with their ſummits converging towards a common centre. Pyrites are uſually diſperſed near beds of iron ore, and ſcattered among clays, and through coal mines. The uppermoſt ſtratum of a coal mine is almoſt always pyritous. All pyrites are eaſily decompoſed. No ſtrong heat is requiſite to drive off the ſulphur which they contain. They almoſt all alter of themſelves when expoſed to the air, eſpecially if the ſituation be moiſt: they ſwell, break, loſe their luſtre, and are covered over with a greeniſh white efflorescence, which is nothing elſe but ſulphate of iron. It appears that this alteration, which has been called the *vitriolization of pyrites*, depends on the joint action of air and water on the ſulphur. Sulphuric acid is thus formed; which, diſſolving the iron, riſes above the pyrites in a form reſembling vegetation,

by

by ſeparating gradually the ſmall pyramids of which the mineral conſiſts. But all pyrites do not effloreſce with the ſame facility. The globulous pyrites, the colour of which is very pale, and the contexture not very cloſe, effloreſce the readieſt. Such as are of a bright copper yellow, and conſiſt of ſmall plates very neatly arranged one over another, effloreſce not without great difficulty, and ſhould be carefully diſtinguiſhed from the former, as they differ from them in colour, form, texture, and other properties.

12. Iron is likewiſe met with in combination with arſenic, and both of them in a metallic ſtate. This ore, which is true *miſpickel*, is white, ſparkling, granulated, or with facets, and does not, like the arſenical pyrites, properly ſo called, contain any ſulphur. Wolfram was formerly thought to be arſenical iron ore; but is now known to be tungſten ore.

13. Iron is ſometimes found in the form of a blue powder; ſometimes of a brighter, and ſometimes a deeper colour. In this ſtate it is called *native Pruſſian blue*. It is mixed with vegetable earths, particularly peat-earth.

14. Laſtly, as iron is more plenteous than any other metal, it is often found mixed with ſand, clay, or chalk; and a great many earths and ſtones are coloured by it.

Iron ores are aſſayed in the dry way in the following manner: After being reduced to powder, they are mixed with twice their own weight of pounded glaſs, one part of calcined borax, and a little powdered charcoal; this mixture is well triturated: it is then put into a crucible, with a little marine ſalt added to cover the crucible, and urged with fire till it melt. When the whole becomes perfectly cool, it is fouud to contain a

ſmall

ſmall ſpherical button of iron, often cryſtallized at the ſurface, and more or leſs malleable.

Bergman propoſes the aſſaying of iron ores in the humid way. He employed the muriatic acid to diſſolve iron, and precipitated it by an alkaline pruſſiate. When there were other metals mixed with the iron, he calcined and ſeparated them by the nitric and the acetous acids; and after that diſſolved the iron by the muriatic acid.

The treatment of iron ores is varied according to the ſtate of the metal. Some ores need no preparation before they be melted; others muſt be pounded and waſhed, ſometimes even roaſted, to render them ſoft and fuſible.

Muddy iron and ſparry iron are wrought in the ſame way; both being melted on coals. The furnaces uſed in melting iron vary in height from twelve to eighteen feet. Their cavity is in the form of two quadrilateral pyramids, with their baſes joined nearly at the middle of the height of the furnace: this cavity is called (in French) *etalage*. A hole, through which the metal may paſs when melted, is perforated through the bottom of the furnace; correſponding to this hole, which is ſtopped with earth, there is a triangular channel cut in the ſand, to receive the metal. The operation begins with putting into the bottom of the furnace a few pieces of burning wood; coals are laid upon the wood; and upon the wood the ore, with ſome matters to promote its fuſion. The matters employed for this purpoſe are uſually calcareous ſtones, called (in French) *caſtine*, with ſome argillaceous ſtones, under the name of *arbue*, and ſometimes quartz or flints. The ore, the ſtones, and the coal, are alternately put into the ſurface, care being

being taken to cover over the whole maſs with a layer of coal, which muſt reach to an equal height with the upper opening of the furnace. Thus diſpoſed, the maſs is urged with two large bellows till it melt. When the iron melts, it paſſes through the coals, and is thus reduced to a metallic ſtate. The ſtony matters, as they melt and vitrify, contribute to the fuſion of the iron, which begins at the narroweſt part of the furnace. The melted metal is collected at the bottom of the furnace into a place called the *crucible;* from this it runs through the aperture in the bottom of the furnace into the reſervoir prepared for it in the ſand. It here forms what is called *caſt iron.* A vitreous matter called *ſlag* paſſes after the iron: it is formed by the vitrification of the gangue of the ore with the earths which were added to facilitate the fuſion of the iron. It is of a green, whitiſh, blue, or yellow colour, which is communicated to it by a part of the oxide of the melted iron.

The iron thus obtained is brittle, and without ductility. Metallurgiſts differ in opinion concerning the cauſe of this property of caſt iron: ſome have ſuppoſed it to depend on the metal being intermixed with ſlag. Others have attributed it to the metal not being entirely reduced, but ſtill containing a portion of oxide. Brandt thought it to be arſenic; and M. Sage thinks it is zinc which renders caſt iron brittle. Bucquet conſidered caſt iron as iron imperfectly reduced, and ſtill containing an intermixture of oxide. Bergman, after examining this iron with great induſtry, concluded its fragility to depend on the intermixture of a certain quantity of an extraneous matter, which he thought to be a peculiar metal, and diſtinguiſhed by the name of *ſyderites:* that

that matter has been diſcovered to be a compound of iron with the phoſphoric acid. Syderites, as we ſhall hereafter ſhow, is likewiſe found in certain irons. The true cauſe of the fragility, fuſibility, granulated texture, and other peculiar properties of caſt iron, has been determined beyond a doubt by the ingenious reſearches of Meſſrs. Vandermonde, Monge, and Berthollet. They have ſhown, that caſt iron contains both oxigene and coal: the laſt of which it has abſorbed when in fuſion in the high furnace. To the various proportions in which it contains theſe two extraneous bodies, caſt iron owes its peculiar properties, and the varieties by which theſe are diverſified.

Metallurgiſts diſtinguiſh various kinds of caſt iron; white, grey, black, &c. They give the name of *ſpeckled iron* to that which is variegated with blackiſh ſpots on a grey ground. White caſt iron is the worſt kind; it is almoſt a ſemi-metal. The grey is between the firſt mentioned and the black; which laſt is eſteemed the beſt, as it affords, the moſt eaſily, iron of a good quality. Theſe differences depends on the various proportions in which the oxigene, and ſtill more the coal, is intermixed with the iron. When the proportion of the charcoal is conſiderable, and it is uniformly intermixed, the caſt iron is then black; when the proportion of the charcoal is leſs, the caſt iron is grey. An imperfect mixture, too haſtily cooled, gives ſpeckled caſt iron. White caſt iron contains the ſmalleſt proportion poſſible of charcoal. The nature and the uſe of caſt iron, and the proceſs for converting it into iron, are affected by all of theſe qualities. The above-mentioned philoſophers have diſcovered, that when caſt iron is melted again, there

there is always ſeparated from it a portion of charcoal intimately combined with iron. This compound, which has been hitherto called *plumbago*, forms a cruſt on the ladles in which the caſt iron is taken out to be cooled.

In order to convert caſt iron into iron, it muſt be purified from the coal and the oxigene which it contains. A ſtrong fire, which may penetrate through the whole maſs, is requiſite to effect this reduction. At an high temperature, the charcoal naturally attracts the oxigene, burns, and is diſengaged with effervescence, in the form of carbonic acid gas. To accompliſh this, the caſt iron is taken to a refining furnace. It is a forge furnace, with its hearth ſomewhat hollow; the caſt iron is put into it, and covered over with a good deal of charcoal, The fire is now blown till the caſt iron be melted; when brought into this ſtate, it is repeatedly ſtirred, with the heat ſtill continued. The ſtirring cauſes it to expoſe more ſurface to the heat; and by this means the charcoal ſeizes more of the oxigene, in conſequence of which it is more completely burnt, and diſengaged in carbonic acid gas. The metal appears alſo to detach from itſelf at the ſame time a portion of *ſyderite*, or phoſphate of iron. It is next to be hammered into bars. The hammering, by compreſſing the particles of the metals, contributes to the ſeparation of the carbure and oxide of iron which it ſtill contains; it conſequently effects what could not be effected by the fuſion from its being incomplete. The iron is repeatedly beaten and heated till it be brought to the deſired form and purity. Forged iron is either ſoft or brittle. Soft iron is very ductile; and when broken, which cannot be done without bending it, it

appears to conſiſt of threads and fibres: this has gained it the name of *nervous iron*. But its nervous appearance is accidental; for even the ſofteſt iron, if broken ſmartly at a ſingle blow, does not appear nervous; while the worſt iron, if broken with due precautions, may be made to put on this appearance. The grain of this metal affords a better criterion of its quality. The other ſpecies of forged iron is more brittle: it has coarſe grains, and appears to conſiſt of ſmall ſcales: This, again, is either brittle when hot, or brittle when cold. The cauſe of its fragility is now known. That which is ſo brittle when cold is known to contain much more ſyderite or phoſphate of iron than what is contained in any other ſort of iron; ſtill, as iron is more ductile, it is found to contain leſs ſyderite; and the ſofteſt iron contains none at all. To ſeparate this ſalt from iron, and to determine its quantity, the metal may be diſſolved in ſulphuric acid, diluted in water; the ſolution, when ſuffered to ſettle, by degrees depoſites the phoſphate of iron in a white precipitate, which may be taken up and weighed.

Iron is artificially converted into ſteel. For this purpoſe, ſhort bars of iron are incloſed in an earthen box, filled with a cement, which is uſually made up of very combuſtible matters; ſuch as ſoot, from chimnies, or coals of animal matters; ſometimes aſhes, calcined bones, marine ſalt, or ammoniac, are added; but theſe matters are often more hurtful than ſerviceable. The box is now ſhut, and expoſed to heat for ten or twelve hours, till the bars become pretty white, and begin to ſoften. In this operation the iron is purified, and completely reduced by means of the combuſtible matters with which it is cloſely ſurrounded. Such parts of it

as

as were not perfectly in a metallic ſtate, are now enabled to return to that ſtate: and the phoſphate of iron, if any yet remains, appears to be now entirely decompoſed. The iron, being thus ſoftened and dilated, abſorbs part of the ſurrounding charcoal; and cemented ſteel appears, therefore, to be a combination of pure iron completely reduced, with charcoal. It differs from iron, as containing charcoal; and from caſt or crude iron, as not containing, like it, any oxigene together with the charcoal. If caſt iron be deprived of its oxigene, and yet ſuffered to retain its charcoal, it will become ſteel; and again, if you add charcoal to pure iron, without adding to it any oxigene, it will likewiſe be converted into ſteel. Steel is much more fuſible than iron; and therefore bars of iron, converted by cementation into ſteel, are ſoftened to ſuch a degree, that the carbonic acid, which is diſengaged in bubbles, ſwells the ſurface of the metal into ſmall cavities, which are ſufficiently diſcernible. The ſteel which exhibits theſe appearances is called *ben-ſteel* *. The differences of ſteel depend on the iron's having been more or leſs completely reduced, on the quantity of the charcoal contained in it, and on its being ſlowly or quickly cooled; tempering compreſſes its particles more cloſely upon each other, and renders it very hard, dry, and brittle.

It is plain, that what renders all theſe preparations neceſſary, is, becauſe this metal is more difficult to melt than any other, adheres much more obſtinately to the oxigenous principle, and has a ſtronger tendency to combine with it.

There are ores, eſpecially black iron ores, ſuch as

* *Acier fondu.*

that of the iſle of Elba, in which the metal is ſo plenteous, and ſo little altered, that there is no occaſion for converting it firſt into caſt iron. It is only ſoftened in a refining furnace, and immediately ſubmitted to the hammer. This is called the *Catalan method.* It cannot be uſed, except with ores which contain but a ſmall portion of extraneous matters that can run into *ſlag.*

Sparry iron ores afford iron ſo pure, and ſo eaſily reducible, that they melt very readily, and greedily abſorb charcoal as they are reduced. They are on this account called *ores of ſteel.*

A very intenſe heat is requiſite to melt iron. Iron filings caſt into the midſt of a pan with burning coals, or even upon the flame of a taper, inſtantly kindle, and produce very lively ſparks; ſuch too are the ſparks which iſſue from a piece of ſteel when ſtruck againſt ſtones. When theſe ſparks are collected upon white paper, they are found to be melted into a kind of droſs or ſcoriæ. This metal, when expoſed to the focus of Trudaine's burning-glaſs, ſuddenly emits flaming and burning ſparks. Macquer, who melted both ſteel and iron in that lens, obſerved ſteel to be the moſt fuſible of the two; which is owing to its being combined with charcoal. When melted iron is ſlowly cooled, it takes, as we have already obſerved, a peculiar cryſtalline form. M. Mongez deſcribes it as a pyramid with three or four ſides.

A ſtream of vital air poured on iron in filings, cauſes it to burn with as much rapidity as the heat of the focus of the lens in the garden *de l'Infante.* If into a bottle filled with vital air you immerſe a piece of iron wire, twiſted into a ſpiral line, with a ſmall bit of light-

ed

ed tinder at one end, the metal ſuddenly takes fire, and burns with a rapidity and a flame which are very remarkable. As in all theſe inſtances of fuſion the iron becomes brittle, is reduced to oxide, and at the ſame time takes a black colour, iron-ſmiths, and all who have any occaſion to work the metal, conſider it as not being fuſible; and with them it is a maxim that iron is abſolutely infuſible. This opinion, however, proves, when ſtrictly examined, to be erroneous; for when ſubmitted to the action of a very ſtrong fire, without being at the ſame time expoſed to the action of air, iron melts almoſt without alteration. In our accurate experiments, we obtain ſmall buttons of ſoft ductile iron.

Iron, though ſo very hard and refractory, is very eaſily calcined or reduced to oxide. As ſoon as it begins to turn red hot, it combines with oxigene, and burns without any diſcernible flame. A bar of iron, after being kept red-hot for a conſiderable time, exhibits on its ſurface ſcales which may be beaten off with the hammer, (and are called by the French workmen *batitures de fer*). The metal of theſe ſcales is but oxidated in part, for they are ſtill liable to be attracted by the loadſtone. A more perfect oxide of iron may be obtained by expoſing filings of ſteel under a muffle; and this will take place ſtill more readily with ſcales of iron. Theſe are converted into a reddiſh brown powder, not liable to be attracted by the loadſtone, which is called *aſtringent ſaffron of Mars*. We call it *red oxide of iron*; and theſcales we called *black oxide*. The black oxide contains from 20 to 25 parts of oxigene to the hundred; the red oxide contains from 32 to 34 of the ſame principle. The oxides of iron differ according as they ap-

proach nearer to the one or the other of theſe two degrees. Some are of a yellow brown colour; others cheſnut; and others, again, of a moſt beautiful red, like carmine. All of theſe oxides, when mixed with earthy matters, and expoſed to a very ſtrong heat, melt into a blackiſh porous glaſs. They are in part reduced when heated ſlowly in cloſe veſſels. However ſhort the time during which they have been expoſed to the air, they give out, when reduced, a certain quantity of carbonic acid; a circumſtance which proves that they attract this acid from the atmoſphere. This acid is alſo produced from the charcoal which the iron contains, and which becomes acid by abſorbing the oxigene diſengaged from them as they are reduced.

Red oxide of iron is very eaſily reduced with the help of combuſtible matters. On being mixed with a little oil, and heated ſlightly in a crucible, they become black, and very ſubject to the attraction of the loadſtone: But in this operation they loſe not all the oxigene which they contain; they only paſs into the ſtate of black oxide.

The pureſt iron ſoon loſes its metallic luſtre when expoſed to humid air: it is then covered over with a pulverulent brown yellow cruſt. This matter is called *ruſt*. Common iron is much more liable to ruſt, than ſteel. The more the particles of the metal are attenuated and divided, the more rapid is the alteration which it ſuffers from air. On this principle is prepared the medicine known in pharmacy under the name of *aperient ſaffron of Mars*. To produce it, iron filings are expoſed to the air, and watered; and by this means they come to ruſt very ſpeedily. It is formed ſtill more quickly

quickly of iron in the ſtate of *Æthiops*, or black oxide, treated in the ſame manner. In this alteration the metal is agglutinated into maſſes, which are levigated before being employed in medicine. The formation of the ruſt of iron was thought to be owing to the action of the air; but it is now known to be water which calcines the metal in this manner. Some experiments peculiar to myſelf lead me to conſider *aperient ſaffron of Mars* as a combination of oxide of iron with carbonic acid. I have diſtilled *this ſaffron of Mars* in a pneumato-chemical apparatus, and obtained from it a large proportion of this acid. The iron was then changed into a black powder, very ſubject to the attraction of the load-ſtone. M. Joſſe, apothecary at Paris, has communicated to the Royal Society of Medicine a ſimilar proceſs for obtaining ſpeedily *martial Æthiops*. He adviſes the making the *aperient ſaffron of Mars* red-hot in a retort, with a balloon perforated with a ſmall hole, fitted, but not luted, to it. By this means the heat diſengages the carbonic acid, which M. Joſſe ſuffers to eſcape through the hole perforated in the balloon; and the iron then remains in the ſtate of black oxide in powder, or *martial Æthiops*. I have by this means often cryſtallized cauſtic potaſh, and ſoda, rubbed over the ſides of the balloon fitted to the retort. In conſequence of the carbonic acid, from the iron, uniting with one or other of the alkalis, the neutral ſalts are formed, to which we have given the name of carbonate of potaſh or of ſoda. I have made many other experiments, and have given an account of them in a particular Memoir, (*Chem. Mem. & Obſerv.* 1784). From all of them I am convinced, that this matter is a true neutral ſalt, formed

by oxide of iron with the carbonic acid. Ruſt ſhould therefore be called *carbonate of iron*, to diſtinguiſh it from the genuine oxides of this metal. This ſalt is preciſely the ſame with what Bergman calls *aerated iron*. This theory, too, has been adopted by Macquer. It explains very naturally how iron comes to contract ruſt ſo ſpeedily in humid and impure air; how it comes to be altered, ſo quickly, and ſo entirely, in places where the air is corrupted by the reſpiration of animals, by combuſtion, or by vapours proceeding from animal matters; as, for inſtance, in ſtables, ſtalls, and houſes of office, &c. Iron is of all metals the moſt liable to alteration from the contact of air, and the alteration is not confined to its ſurface. Very thick bars of iron are often ruſted half way through.

Water acts powerfully on iron when cold. It divides it, and even diſſolves a part of it, according to the experiments of M. Monnet. The purer the iron is, and the more air the water contains, ſo much the more of it does it diſſolve. When iron is for ſome time ſtirred about in water, it appears to be divided into very minute parts; and on decanting the water, which is a little turbid, it depoſites a very fine black powder, which has received the name of *Lemery's martial Æthiops*. This powder muſt be carefully dried by a moderate heat, and in a cloſe veſſel, ſuch as an alembic, leſt the contact of the air ſhould ruſt it. This martial Æthiops is very ſubject to the attraction of the loadſtone; it is a black oxide of iron formed by water. As this operation is very tedious and delicate, various chemiſts have attempted to ſimplify it. Rouelle, in making up this preparation, made uſe of the *mouſſoirs de la Caraye*, and by that means

means obtained a very fine *Æthiops*, in much leſs time than is conſumed in Lemery's proceſs. I believe M. Joſſe's method, which is much more expeditious, might be advantageouſly ſubſtituted in its place. We will hereafter give ſome other proceſſes for preparing *martial Æthiops*. Lemery's is effected by an actual decompoſition of water; hydrogenous gas is diſengaged, and the iron is oxidated by abſorbing twenty-five parts of oxigene to a hundred. We will very ſoon treat more at length of this decompoſition of iron by water.

We have already mentioned, that when ſteel in bars is heated to a certain degree, and ſuddenly immerſed into cold water, it becomes very hard, and very brittle. The hotter the ſteel, and the colder the liquour into which it is immerſed, ſo much the more eminent do theſe qualities become. This operation is called *tempering*. Steel may at pleaſure be cauſed to aſſume any degree of hardneſs. We can alſo deprive it of its *temper*, by heating it to the ſame temperature at which it was tempered, and ſuffering it to cool ſlowly. This effect of water on ſteel appears to depend on the ſudden cooling producing a change in the diſpoſition of its parts, and injuring its cryſtallization. All metals admit of being hardened by tempering; but the more infuſible the metal, ſo much the more eminent the degree in which it acquires this quality. Iron, therefore, is more ſuſceptible of it than any other.

About two years ſince, a much ſtronger action was diſcovered to take place between water and iron. M. Lavoiſier putting iron and water together into bell-glaſs above mercury, obſerved that the iron ruſted, and the water decreaſed in quantity in proportion as an elaſtic

fluid which filled the upper part of the apparatus was diſengaged. The fluid diſengaged proved to be *inflammable gas.* The iron had gained an additional weight, and was oxidated: M. Lavoiſier conjectured, that the water might contain oxigene, and that the inflammable gas, the other principle of the water, might be diſengaged, in conſequence of the oxigene uniting with the iron. He afterwards made a more deciſive experiment, in conjunction with M. Meuſnier: in that experiment, water in vapour introduced into a gun-barrel made red-hot, afforded a large proportion of *inflammable gas:* The inner part of the gun was found to have acquired additional bulk, and was become black, brittle, and lamellated, much like the iron ore of the iſle of Elba: The metal was found to have gained an increaſe of weight; and the additional weight which it had acquired, taken together with the weight of the *inflammable gas*, correſponded preciſely to that of the water decompoſed. The portion of iron oxidated by this means was found ſeparate from that which had not undergone the ſame alteration. It formed an interior cylinder, thicker than the exterior part; and differing greatly from it in texture, colour, conſiſtency, and form. In order to ſucceed in this experiment, it is requiſite to heat the iron to a white red; for heat contributes greatly to the ſeparation of the principles of the water. And when the gun-barrel is not thoroughly red-hot, and the water not in an highly elaſtic ſtate when it paſſes through it, no *inflammable gas* is diſengaged, nor is the water decompoſed. This has happened with various philoſophers; who not making the iron hot enough, and introducing the water into it in a liquid ſtate, have not obtained the ſame reſults as

M.

M. Lavoiſier, and have of conſequence denied water to be decompoſable, though Syntheſis concurs to juſtify M. Lavoiſier's inferences from analyſis, as has been incontrovertibly ſhown by the ſame gentleman and M. Mongez. There are many other occaſions on which water is, in a like manner, ſeparated into its conſtituent principles, and gives riſe to many very important phænomena, of which we ſhall hereafter have occaſion to take notice. Such is the experiment by which water was diſcovered to be a compound conſiſting of 0,14 of hydrogene, with 0,86 of oxigene.

Iron does not combine in its metallic ſtate with earthy or ſtony matters; but oxide of iron facilitates the vitrification of all kinds of ſtone; communicating to them a green or brown colour. The colours which oxide of iron communicates to other bodies are various, according as it is more or leſs completely oxidated. This oxide poſſeſſes likewiſe the property of aſſuming and communicating more or leſs conſiſtency to thoſe ſtones with which it is naturally or artificially mixed, and diluted by means of water.

Neither barytes, magneſia, nor lime, acts obſervably upon iron.

The pure fixed alkalis and ammoniac, when diſſolved in water, act in a ſenſible manner on this metal. In the courſe of a few days digeſtion on it, the liquors become foul, and give a precipitate of a ſmall portion of *Æthiops*, or black oxide of iron: And, as has been obſerved by the chemiſts of the Academy of Dijon, a certain quantity of hydrogenous gas is diſengaged during the action of theſe ſubſtances; a circumſtance which proves, that the water contributes to it, as the hydrogenous gas can be

be given out only in conſequence of its decompoſition; to which no doubt the alkalis contribute.

Iron may be diſſolved in any of the acids. M. Monnet has obſerved, that the concentrated ſulphuric acid cannot act on this metal, unleſs it be boiling. On diſtilling this mixture to dryneſs, there are found in the retort ſublimated flowers of ſulphur, and ſulphate of iron in a white maſs, which may be partly diſſolved in water, but which being decompoſed by heat, affords no cryſtals. The ſulphuric acid diluted in two parts of water, readily diſſolves iron filings cold; at the ſame time, when the metal is diſſolved, a conſiderable quantity of hydrogenous gas is diſengaged. By putting a lighted taper to the mouth of the matraſs, after keeping it ſtopped for ſome time with the hand, it may be made to detonize with a conſiderable noiſe. This gas burns with a reddiſh flame, ſometimes emitting very ſmall ſparks, like thoſe of iron filings. Macquer, Bergman, and Mr Kirwan, think that in this inſtance of combination the ſulphuric acid diſengages a great part of the phlogiſton of the iron, and that the *inflammable gas* belongs ſolely to this metal. This opinion appears to have been built on the belief, that *inflammable gas* might be extracted from iron alone, without any intermedium, merely by the action of fire. But it is at preſent a well eſtabliſhed fact, that the hydrogenous gas, diſengaged from iron by heat, is always in exact proportion to the water it contains; and it is no leſs certain, that water added to ſulphuric acid gives out, in conſequence of being decompoſed, hydrogenous gas. 1. Becauſe the concentrated ſulphuric acid affords only ſulphureous gas. 2. Becauſe in this ſtate it cannot act upon iron without the aid of

heat, and even then acts upon it very faintly. 3. Becauſe, whenever water is added, the action becomes more rapid, and hydrogenous gas is produced. 4. Laſtly, becauſe concentrated ſulphuric acid is in part decompoſed by iron when there is no water added; whereas, when water is added to the ſolution, the acid remains without diminution, and only combines with the oxide of iron. The proof of this laſt fact is, that the ſame quantity of alkali is required to ſaturate this acid after it has acted on iron as before. In this operation, therefore, it is the water which oxidates the iron, as was long ſince conjectured by M. de la Place; and has been fully proved by Meſſrs Lavoiſier and Meuſnier.

While the ſulphuric acid diluted in water acts upon iron, a portion of the metal is precipitated in a black powder, which was taken by Stahl for ſulphur, and has been found by M. Monnet to be *martial Æthiops*. That black oxide appears to be more than ſufficient for the ſaturation of the acid. As ſoon as one part of the iron is combined with one of the acid, although the acid be not nearly ſaturated, yet the ſolution ceaſes, and it no longer acts upon the metal. M. Monnet, who firſt made this obſervation, remarks, that when water is poured into the mixture, the acid begins again to act upon the metal. The cauſe of this phænomenon is, that the water which was united with the ſulphuric acid has been abſorbed by the ſulphate of iron, which is already formed, while the acid which remains unſaturated cannot act upon the iron, till by the addition of a new quantity of water more of the metal be reduced to oxide. The ſulphuric acid diſſolves more than half its own weight of iron. This ſolution, after being filtered and evaporated,

affords

affords by cooling a tranſparent ſalt, of a beautiful green colour, in rhombic cryſtals. This is the *martial vitriol*, or *green copperas* of commerce. We call it ſulphate of iron.

People do not take the trouble of making up this ſalt artificially, becauſe nature ſupplies it in abundance, and it is eaſily extracted from *martial pyrites*. All that is requiſite is, to leave thoſe ſulphurs expoſed for ſome time to the air. The moiſture of the atmoſphere contributes to their decompoſition; they become covered with a white efflorescence, which needs to be diſſolved in water, and cryſtallized, before it can afford ſulphate of iron. This decompoſition of pyrites depends, according to Stahl, on a double affinity. Sulphur is with him a compound of *phlogiſton* and *vitriolic* acid. Neither water or iron, when taken each by itſelf, can decompoſe ſulphur: But when theſe two ſubſtances are made to act upon it together, the iron detaches, and attracts to itſelf the phlogiſton of the ſulphur, and the *vitriolic* acid combines with the water to diſſolve the metal. Such of the pyrites as are leſs diſpoſed to efflorescence, among which are the brilliant pyrites, effloreſce readily after being deprived by roaſting of a part of the ſulphur which they naturally contain. The *vitriol* is ſeparated from it by waſhing. The ſolution of this ſalt depoſites at firſt a certain quantity of iron in the ſtate of ochre. The liquor is not evaporated and cryſtallized till after this depoſitum be precipitated. The modern opinion concerning the efflorescence of pyrites is, that the ſulphur, which in them is divided as in its combinations with alkaline ſubſtances, combines with a portion of oxigene to form ſulphuric acid, which being diluted

by

by the atmoſphere, enters into union with the iron, not without exciting heat, and diſſolves it. What adds a very conſiderable weight to this opinion is, that the contact of air is neceſſary to the efflorescence of pyrites, and that moiſture, which contributes greatly to their *vitriolization*, acts in this inſtance in the ſame manner as in the ſolution of iron. Such is the origin of the hydrogenous gas, which is diſengaged in this operation when performed *in vacuo*.

Sulphate of iron has a green emerald colour, and a very aſtringent taſte. It ſometimes reddens ſyrup of violets; but it does not uniformly produce this effect. From the experiments of Kunckel and M. Monnet, it appears that theſe cryſtals contain a quantity of water equal to more than half the weight of the ſalt. If this ſalt be ſuddenly expoſed to a pretty ſtrong heat, it becomes liquid, like any of the other ſalts which are more ſoluble in heat than in cold: when dried, its colour is a whitiſh grey. If it be heated at a more intenſe fire, it gives out ſo much of its acid in the form of ſulphureous gas, and becomes red; in this ſtate it is called *colcothar*. Sulphate of iron, when calcined till it becomes red, attracts the moiſture of the atmoſphere, in a very ſenſible manner, by means of the ſulphuric acid which it contains. When diſtilled in a retort, and in a reverberating furnace, this ſalt affords at firſt a water which is faintly acid, and is called *dew of vitriol*. The balloon muſt be changed, when we wiſh to obtain the concentrated ſulphuric acid ſeparately; which, when the heat is very intenſe, appears black as it paſſes into the receiver, and exhales a ſuffocating ſmell of volatile ſulphureous acid. What enables it to diſplay theſe

phænomena is, according to the pneumatic theory, its having loſt a part of its oxigene, which has become fixed in the iron. Towards the end of the operation, the acid diſtilled aſſumes a concrete cryſtalline form, and it is now called *glacial ſulphuric acid.* This experiment, which is deſcribed by Hellot, did not ſucceed with M. Baumé; but among chemiſts in general it is conſidered as certain and infallible. The glacial ſulphuric acid, when diſtilled in a ſmall retort, gives out ſulphureous gas, and becomes white and fluid. It owes its concrete ſtate to the preſence of this gas. It combines with water with hiſſing and heat, and on this occaſion, too, gives out ſulphureous gas. Such is Northauſen's ſuming *oil of vitriol*, and the concrete ſalt obtained from it by a moderate heat, of which I have given an analyſis in a Memoir publiſhed among the Memoirs of the Academy for the year 1785.

The reſidue remaining after the diſtillation of ſulphate of iron is red, and reſembles colcothar. When waſhed with water, there is ſeparated from it a white ſalt, but little known, and called *colcothar ſalt*, or *fixed ſalt of vitriol.* What remains is a red inſipid earth, which is pure oxide of iron, and is called *mild earth of vitriol.*

Sulphate of iron, when expoſed to the air, becomes ſomewhat yellow, and is gradually covered with ruſt, by abſorbing oxigene from the atmoſphere. By this abſorption of oxigene, it is gradually more and more calcined, till it become incapable of remaining united with the ſulphuric acid. A ſolution of this ſalt exhibits the ſame phænomenon when brought into contact with the atmoſphere; and either the one or the other may be uſed as an eudiometer.

Cold

Cold water diſſolves a quantity of this ſalt equal to half its own weight: hot water diſſolves ſtill more of it: but when ſufficiently impregnated, it appears to be rendered turbid by a quantity of ochre more or leſs conſiderable. This ochre is ſeparated from it by filtration: and the ſolution, when cooled, gives pale green tranſparent rhomboidal cryſtals. The ſupernatant liquor affords, by evaporation, a new parcel of cryſtals: and after it is deprived of all that it can afford by cryſtallization, there remains a blackiſh brown, or a brown yellow mother water, not ſuſceptible of cryſtallization. When evaporated by a ſtrong heat, and ſuffered to cool, this mother water forms a ſoft unctuous maſs, which powerfully attracts the moiſture of the atmoſphere. When this maſs is thoroughly dry, it affords a greeniſh yellow powder. According to M. Monnet, the mother water of ſulphate of iron contains iron in the ſtate of a perfect oxide. He made himſelf certain of this fact, by forming directly, with the help of heat, a ſolution of genuine oxide of iron in this acid. The ſolution is brown, and not ſuſceptible of cryſtallization.

The oxide of iron may be ſeparated from the mother water, not only by aluminous earth, but alſo by copper and iron filings, to which perfect ſulphate of iron is not liable.—A ſtrongly ſaturated ſolution of this perfect ſalt, if expoſed to the air, changes, in a certain ſpace of time, into a mother water of the ſame nature with the two laſt-mentioned, by attracting oxigene from the atmoſphere.

Sulphate of iron is decompoſable by lime and alkalis. Lime-water poured into a ſolution of this ſalt produces a precipitate in flakes of a deep olive green colour; a portion

portion of the precipitate is again diſſolved in the water, and communicates to it a reddiſh tinge. In the years 1777 and 1778, I preſented to the Academy two Memoirs on precipitates of iron obtained by cauſtic alkalis, or by alkalis not cauſtic, in which I have accurately deſcribed the phænomena which attend theſe precipitations, and the ſtate of the iron in theſe different circumſtances; I ſhall here give the chief facts which they afford in relation to ſulphate of iron. Cauſtic fixed alkali precipitates the ſulphuric ſolution of iron in dark green flakes, which are again diſſolved in the alkali, forming a kind of martial tincture of a very beautiful red colour. When a ſmaller portion of the alkali is put into the ſolution, the precipitate may be taken up and converted into blackiſh *Æthiops*, or black oxide of iron, by drying it rapidly and in cloſe veſſels. If theſe two precautions were neglected, the iron would very ſoon become oxide, on account of its being moiſt and divided. Potaſh, ſaturated with carbonic acid, or carbonate of potaſh, forms a greeniſh white precipitate, which does not diſſolve again in the alkali. This difference is owing to the carbonic acid, which unites with the iron as faſt as it is ſeparated from the alkali by the ſulphuric acid. Pure or cauſtic ammoniac produces a precipitate from a ſolution of ſulphate of iron in water, of a deep blackiſh green, and which does not diſſolve again in the ſalt. By drying it ſuddenly, and in cloſe veſſels, it may be obtained black, and liable to be attracted by the loadſtone. The precipitate formed by concrete ammoniac, or ammoniacal carbonate, is of a greeniſh grey colour; a part of it is again diſſolved in the ſalt, and communicates to it a red tinge; ſo that the phænomena

phænomena which ammoniac produces in this ſolution, are in one reſpect directly oppoſite to thoſe of the fixed alkalis: cauſtic fixed alkali diſſolves the precipitated iron very readily; carbonated potaſh, not without the greateſt difficulty.

Aſtringent vegetable matters, ſuch as nut-galls, ſumac, huſks of nuts and pomegranates, quinquina, cypreſs-nuts, logwood, tea, &c. cauſe ſulphate of iron to yield a black precipitate. This precipitate, which cannot be miſtaken for iron, is ſo much attenuated as to remain ſuſpended in the liquor. On adding to this mixture a little gum-arabic, the iron precipitate is permanently ſuſpended, and the compoſition forms the black liquor known under the name of ink. We do not yet certainly know what paſſes on this occaſion. Macquer, M. Monnet, and many other chemiſts, think the precipitate of ink to be combined with ſome principle of the nut-gall which diſengages it from the acid. They appear with ſome reaſon to think that principle in an oily ſtate. M. Guanetti, a phyſician at Turin, has made a number of experiments on iron precipitated by aſtringents from its ſolutions. The reſult of his reſearches, which he has given in his analyſis of the waters of St Vincent, proves that this precipitate is not liable to be attracted by the loadſtone: that it becomes ſo, however, when heated in a very cloſe veſſel; that it is ſoluble in acids without effervescence; and that the ſolution no longer receives a black tincture from nut-galls: from which facts it may be inferred, that the iron is combined with the aſtringent principle, and that they exiſt together ſomewhat in the ſtate of a neutral ſalt. In the third Volume of the Elements of Chemiſtry, by the Aca-

demy of Dijon, there is a ſeries of experiments on the aſtringent vegetable principle, which ſeem to repreſent this ſubſtance as of a ſimilar nature with acids. According to thoſe chemiſts, it reddens vegetable blue colours; combines with alkalis; decompoſes ſulphurs; diſſolves, and appears to neutralize metals; decompoſes all ſolutions of metals with peculiar phænomena; aſcends in diſtillation, without loſing its power of acting on metals, and diſplays a vaſt number of other properties which we have not here room to enlarge upon.

The experiments and inductions of the academicians of Dijon have ſince been confirmed by the reſearches of Scheele. That celebrated chemiſt has diſcovered, that the ſimple infuſion of nut-galls in water, ſeparates from it a peculiar acid, ſuſceptible of cryſtallization, which detaches iron from any other acids, and communicates to it a black colour, by bringing it nearer to a metallic ſtate. We call this ſalt the *acid of galls*, or the *gallic acid*. Its hiſtory will occur in the vegetable kingdom.

A phænomenon ſtill more difficult to underſtand than the action of nut-gall on ſulphate of iron, is the decompoſition of this ſalt by an alkali calcined with bullock's blood. By this means we obtain a precipitate of a beautiful blue colour, and inſoluble in acids. This precipitate is called *Berlin*, or *Pruſſian blue*, becauſe it was firſt diſcovered in the city of Berlin. Stahl relates, that a chemiſt, of the name of Dieſbach, happening to borrow from Dippel a quantity of fixed alkali to precipitate a ſolution of cochineal, Dippel gave him alkali on which he had diſtilled his animal oil. The ſalt cauſed Dieſbach's ſolution to yield a blue precipitate. Dippel inquired into the cauſe, and prepared, by a ſimple proceſs, the

the Pruſſian blue, which was made known to the world in the year 1710, in the Miſcellanies of the Academy of Berlin; but the mode of preparation was not communicated. Chemiſts laboured eagerly to diſcover the proceſs for preparing it, and at length ſucceeded. In the year 1724, Woodward publiſhed, in the Philoſophical Tranſactions, a proceſs for preparing this colouring ſubſtance.

To make Pruſſian blue, mix four ounces of nitre, fixed by tartar, with as much dried bullock's blood. Calcine this mixture in a crucible till it be reduced to a coal, and ceaſe to emit flame. Waſh it with as much water as may be requiſite to diſſolve the whole of the ſaline matter, which is called *phlogiſticated alkali*, or *colouring lixivium*; and let this lixivium be concentrated by evaporation. Next diſſolve two ounces of ſulphate of iron, and four ounces of aluminous ſulphate, in a pint of water. Mix this ſolution with the alkaline lixivium; a greeniſh depoſitum is produced, which muſt be ſeparated by the filter and muriatic acid poured upon it. The depoſitum then takes a darker and more beautiful blue colour; and is to be dried by a moderate heat, or in the air.

Many chemiſts have ſince attempted both to prepare and to form a theory of Pruſſian blue. As to its preparation, it is at preſent known, that many other ſubſtances render alkali capable of producing a blue precipitate of iron.

Geoffroy, in the Memoirs of the Academy for the year 1725, ſays, that he found all burnt coals of animal matters capable of communicating this property to alkalis. M. Baumé aſſerts, that *phlogiſticated alkali* may be pre-

pared with the coals of vegetable ſubſtances by a ſtronger heat. Spielman has made it with bitumens; Brandt with ſoot. The manufactories of Pruſſian blue are very numerous; and in each of them, it would appear, different methods are employed in the preparations. M. Baunach informs us, that in Germany the hooves, horns, and hides of cattle, are uſed for this purpoſe. All animal matters, however, do not appear equally proper for the Pruſſian lixivium. I have attempted ineffectually to prepare it with the bile in the ſame manner as with the blood of bullocks. What I obtained was an alkali, which produced in a ſolution of vitriol a greeniſh white precipitate; and the precipitate was entirely diſſolved in the muriatic acid.

Chemiſts differ greatly concerning the theory of Pruſſian blue. Brown and Geoffroy thought it to be the *phlogiſtic* part of iron extricated by the lixivium of the blood, and united with the aluminous earth. Abbé Menon thought it to be alkali. Macquer, in a Memoir which has deſervedly been conſidered as a maſter-piece by every chemiſt, and is inſerted among the Memoirs of the Academy for the year 1752, has refuted the opinions of thoſe chemiſts. He thinks Pruſſian blue to be nothing but iron, combined with an exceſs of the inflammable principle which it receives from the *phlogiſticated* alkali, and the alkali from the bullock's blood. He obſerves, 1. That Pruſſian blue, when expoſed to heat, loſes its colour, and becomes ſimply iron again: 2. That this blue is inſoluble even by the ſtrongeſt acids: 3. That alkalis are capable of diſſolving the colouring matter of Pruſſian blue and abſorbing it till they be ſaturated. For this it is ſufficient to heat an alkaline

kaline lixivium upon Pruſſian blue till the alkali become unfit to diſcolour it. Alkali, when thus ſaturated with the colouring matter of Pruſſian blue, is found to have loſt moſt of its properties. It is no longer cauſtic; it does not effervesce with acids; of the earthy ſalts, it decompoſes only ſuch as have barytes for their baſe; it precipitates all metallic ſalts; and this precipitation appears to take place by virtue of a double affinity, the affinity of the acid with the alkali, and the affinity of the metallic oxide with the colouring part of that ſalt. Alkali is thus capable of deſtroying the colour of a twentieth part of its weight of Pruſſian blue; and is then ſaturated with colouring matter. The acids diſengage from it a ſmall quantity of blue ſediment; and the ſulphate of iron is then inſtantly precipitated in perfect Pruſſian blue.

In regard to alkali prepared in the common way, Macquer obſerves, that it is far from being completely ſaturated with colouring matter; and that, from this circumſtance, it produces at firſt a green precipitate from the ſolution of ſulphate of iron. In fact, the portion of the alkali which is ſaturated does give a blue precipitate; but the portion which is not ſaturated precipitates iron in the ſtate of ochre, which gives a green tinge to the blue precipitate, by intermixing the blue with yellow. According to this ingenious theory, the acid poured on the precipitate, ſerves to diſſolve that portion of it which is not in the ſtate of Pruſſian blue, and to improve the colour of that which is. The alum, which is added to the ſolution of ſulphate of iron, ſaturates the alkali which is not already ſaturated with colouring matter; and the earth of this laſt added ſalt,

being precipitated with the Pruſſian blue, brightens its dye. As it is neceſſary to pour acid on the precipitate of ſulphate of iron, in order to brighten Pruſſian blue, that acid may be added to the alkali before it be employed to precipitate the iron; for while the acid ſaturates the pure part of the alkali, it does not combine with that which is impregnated with colouring matter, and is capable of inſtantaneouſly forming fine Pruſſian blue. This *phlogiſticated* alkali may be alſo ſaturated with bullock's blood, by digeſting it over Pruſſian blue till it ceaſe to diſcolour it. Macquer has recommended this alkali, ſaturated with acid, as a good teſt for determining the preſence of iron in mineral waters: but M. Baumé has obſerved, that this liquor itſelf contains a certain quantity of Pruſſian blue, by which it may occaſion miſtakes when applied to this purpoſe. He propoſes, therefore, to digeſt it for ſome time with a little vinegar, by a moderate heat, in order that it may depoſite the blue matter which it contains. Such were the reſults of Macquer's ingenious experiments on Pruſſian blue; but that celebrated chemiſt was himſelf very ſenſible of what was wanting, more eſpecially to explain the nature of the colouring ſubſtance. He could not be perſuaded to conſider that ſubſtance as pure phlogiſton; for he could not conceive how, as is pretended in this hypotheſis, iron, ſuperſaturated with the phlogiſtic principle, could all at once loſe both the property of obeying the attraction of the loadſtone, and that of being ſoluble in acids, which, according to Stahl, this metal owes to its containing phlogiſton. M. de Morveau, in his excellent diſſertation on phlogiſton, has made the firſt attempt to determine the nature of the colouring

part

part of Pruſſian blue. He obtained, by diſtilling two drachms of this compound, twenty-two grains of a yellow empyreumatic liquor, which effervesced with alkaline carbonates, and communicated an high red colour to blue paper, but has not been once mentioned by Geoffroy or Macquer, though they likewiſe diſtilled Pruſſian blue.

M. Sage, in the year 1772, ſent to the Electoral Academy of Mayence, a Memoir on *phlogiſticated alkali*, in which he calls it animal ſalt. The lixivium of fixed alkali, treated with blood, and ſaturated by digeſtion on Pruſſian blue, as directed by Macquer, is, according to M. Sage, a neutral ſalt, formed by the animal acid with fixed alkali. It affords, by ſenſible evaporation, cubic cryſtals, either octohædral, or in priſms with four faces, terminating in pyramids having the ſame number of ſides. This ſalt decrepitates on coals: by a violent heat, it melts into a ſemi-tranſparent maſs, ſoluble in water, and proper for making Pruſſian blue. M. Sage thinks, that it is the phoſphoric acid which neutralizes the alkali in this neutral ſalt; becauſe, when the mixture of alkali with bullock's blood is made very hot, it melts, and exhales an acrid vapour, attended with white brilliant ſparks, which, in his opinion, are nothing but phoſphorus in flame: This opinion concerning the nature of the acid of the Pruſſian alkali would be eſtabliſhed as a certain truth, if, on the one hand, it afforded phoſphorus when diſtilled with coal, a phænomenon which in that caſe Pruſſian blue might likewiſe exhibit; and if, on the other hand, Pruſſian blue could be formed by combining phoſphate of potaſh, or ſoda, with a ſolution of iron. But, as M. Sage has given no

experiments

experiments to this purpoſe in his Memoir, his theory cannot be admitted.

The chemiſts of the Academy of Dijon have, in their Elements, adopted a part of this laſt doctrine: They conſider the *phlogiſticated* lixivium as a neutral ſalt. They recommend cryſtallizing it by evaporation, in preference to purifying it by vinegar, as has been propoſed by M. Baumé. This ſalt, according to them, is very pure; when caſt on nitre in fuſion, it cauſes it to detonize. They ſay nothing of its decompoſition, or the nature of its principles; they call it cryſtallized Pruſſian alkali.

Bucquet, on precipitating with muriatic acid, and afterwards filtrating a lixivium prepared for Pruſſian blue, obſerved, that the alkali, though apparently pure after this operation, and without any appearance of Pruſſian blue, yet depoſited a blue powder. After filtrating it above twenty times in the ſpace of two years, in order to ſeparate the blue precipitated after each filtration, he at length found the liquor to be no longer capable of forming Pruſſian blue with the ſolution of ſulphate of iron. I have kept by me for more than eight years, a ſmall portion of this lixivium; during the two laſt of theſe years, it has given no precipitate, but has depoſited a light bluiſh coating on the ſides of the phial, and has maintained the ſame colour. I have had occaſion to obſerve this phænomenon twice ſince I heard Bucquet mention it in his lectures: and I believe it to be invariable. The Duke de Chaulnes ſhowed Macquer a colouring lixivium, which, on being previouſly mixed with an acid, became incapable of affording Pruſſian blue. That chemiſt thinks, that the lixivium which exhibited

this

this phænomenon muſt have been prepared in metal veſſels. Bucquet concluded from the facts which he is above mentioned to have obſerved, 1. That the Pruſſian blue is entirely contained in the alkali employed to precipitate the ſulphate of iron; 2. That acids alone are ſufficient to ſeparate the alkali: 3. That when this alkali has, in the courſe of a certain time, depoſited all the colouring matter which it contained, it is no longer fit for affording Pruſſian blue.

The *Journal de Phyſique*, for the month of April 1778, contains obſervations on Pruſſian blue, by M. Baunach, apothecary at Metz, which contribute greatly to ſupport Bucquet's opinion. After deſcribing the proceſs of the German manufactories for preparing Pruſſian blue, M. Baunach affirms, that the lixivium prepared in thoſe manufactories by the fuſion of alkali, and the hoofs, horns, and hides of cattle, cauſes all metals, and even calcareous earth, to yield a blue precipitate. This alkali, after precipitating metals, diſſolves them; and they may be ſeparated by the muriatic acid, when they will diſplay a very beautiful blue colour. The ſingular facts related in that Memoir, ſuch as the diſtillation of the Pruſſian blue produced by this lixivium, which affords neither oil nor ammoniac; the ſolubility of the blue precipitate formed when muriatic acid is poured on this lixivium in nitric acid; the circumſtance of calcareous earth being found in the nitric acid which has deſtroyed the blue; and the exiſtence of a peculiar phlogiſticated earth in it which he could not diſſolve; theſe facts, taken together, ſeem to ſuggeſt, that this blue is not of the ſame nature with that which is precipitated from the common phlogiſticated lixivium, which

which Macquer found to contain iron, and which can be produced only from blood.

Since theſe experiments on Pruſſian blue, Scheele has made a new ſeries of reſearches on the nature of this compoſition, which, together with ſome obſervations of which I have not yet ſpoken, throw much new light on its nature.

1. Common Pruſſian blue, diſtilled by naked fire, affords a very large quantity of hydrogenous gas, together with oil, ammoniacal carbonate, and a little acid phlegm. This gas burns with a blue colour, like that which riſes from marſhes; its ſmell is empyreumatic: lime-water communicates to it the property of burning with a red flame, and detonizing in the air, for it abſorbs from the lime-water part of its carbonic acid. M. de Laſſone has conſidered the gas of Pruſſian blue as a peculiar inflammable gas. Pruſſian blue, after this analyſis, is in the form of a blackiſh powder, ſubject to the attraction of the loadſtone. M. de Morveau has obſerved, that it becomes orange before taking this colour. He is even of opinion, that Pruſſian blue, converted by heat to orange, might be advantageouſly employed in painting.

2. Ammoniac heated above Pruſſian blue decompoſes it by ſeizing on the colouring matter, and leaving the iron in the ſtate of brown oxide. Macquer made this fact known in the year 1752. Meyer, following him, has given the name of *tinging* liquor to this volatile alkali ſaturated with blue colouring matter, and recommends the uſe of it in analyſing mineral waters. I have obſerved, that when cauſtic ammoniac is diſtilled on Pruſſian blue, the liquor which paſſes does not give a blue colour

to

to ſolutions of iron; from which it follows, that the colouring matter is not ſo volatile as ammoniac. When only a part of this ſalt is extracted by diſtillation, the reſidue is of an olive green colour: on diluting it in diſtilled water, and filtrating the liquor, it is found to have impregnated the water with colouring matter; and it accordingly affords a very lively Pruſſian blue with ſulphate of iron.

3. In the year 1780, I diſcovered, that when lime-water is digeſted on Pruſſian blue, it diſſolves the colouring matter, if aſſiſted with a little heat. The combination is very rapid: the lime-water acquires a colour, and the Pruſſian blue takes the appearance of ruſt. This lime-water, when filtrated, is of a fine bright yellow colour: It does not turn ſyrup of violets green; it has not an alkaline taſte, and is not precipitated by the carbonic acid; it does not combine with other acids: in a word, it is neutralized by the Pruſſian colouring matter; and when poured on a ſolution of ſulphate of iron, it affords a fine blue, which does not need to be brightened by an acid. Scheele has mentioned this Pruſſian lime-water, without knowing any thing of my experiments; notwithſtanding of my having given an account of the reſult in my Elements of Chemiſtry, printed in the year 1781. He is of the ſame opinion with me, that this combination is the very beſt that has been propoſed for determining the preſence of iron; becauſe it contains either none, or at leaſt very little, Pruſſian blue completely formed.

5. The cauſtic fixed alkalis inſtantaneouſly deſtroy, in the cold, the colour of Pruſſian blue. I have obſerved that a pretty lively heat is produced on this occaſion; that the alkalis, when pure, diſcolour much more Pruſſian

ſian blue, than when ſaturated with carbonic acid; and that they afford much more blue with ſolutions of iron, when pure, than when carbonated.

6. I found magneſia likewiſe to poſſeſs the property of diſcolouring Pruſſian blue, but not in ſo eminent a degree as lime.

7. Pruſſian blue in powder, if caſt on nitre in fuſion, produces ſome ſparks; from which we may infer, that it contains a combuſtible matter.

8. Pruſſian blue, prepared without alum, becomes, in a high degree, ſubject to the attraction of the loadſtone, on being ſlightly calcined; but common Pruſſian blue never acquires this property by the action of fire.

9. Pruſſian blue diſcoloured by alkaline matters, and in the ſtate of oxide of iron, regains a part of its blue colour if an acid be poured into it. The cauſe of this phænomenon ſeems to be, that all the colouring matter has not been carried off by the firſt action of the alkalis; and a portion is ſtill retained among the particles of the oxide of iron.

All theſe facts ſhow, that the colouring part of Pruſſian blue acts as a peculiar acid, which ſaturates alkalis, thereby forming neutral ſalts. This is the opinion of a great many chemiſts, particularly of Scheele, whoſe reſearches on this matter I am now to give ſome account of. That celebrated chemiſt has ſhown by his experiments, 1. That the lixivium of blood, or phlogiſticated alkali, is decompoſed by the carbonic acid of the atmoſphere; and that all other acids ſeparate from it the colouring part. 2. That this colouring part is fixed, and retained in the lixivium, by a ſmall quantity of pure iron, or ſulphate of iron. 3. That when it is diſengaged

by

by acids, by means of diſtillation, it fills the balloons with a vapour which makes ſolutions of iron to yield a blue precipitate. 4. That when Pruſſian blue, or the lixivium of blood, is diſtilled entirely, it affords, together with the colouring matter, other products which alter this matter, ſuch as ſulphur; and that therefore the colouring matter cannot be obtained pure by this proceſs. 5. That Pruſſian alkalis, diſtilled with ſulphuric acid, precipitate a good deal of Pruſſian blue, and afford a liquor impregnated with the colouring matter: the blue precipitated in this operation depends on the iron diſſolved in theſe triple ſalts, or compounds of alkali, colouring matter and iron. 6. That oxide of mercury, or red precipitate, carries off the colouring matter of Pruſſian blue by ebullition, in a quantity of water equal to twice the weight of the two ſubſtances; and that by diſtilling this mercurial Pruſſian lixivium with iron and ſulphuric acid, the iron reduces the mercury after the acid has diſengaged the colouring part: the colouring matter being diſſolved in the water of the receiver as faſt as it is diſengaged, retains a portion of ſulphuric acid; to ſeparate it, Scheele mixes a little chalk with the colour, and diſtils it by a moderate fire; the colouring matter then paſſes very pure into the receiver: and as it is diſengaged in the ſtate of an elaſtic fluid, according to what has been obſerved by M. Monge, it may be received and diſſolved in water with the tubes and the apparatus which we have already repeatedly deſcribed.

After theſe experiments on the affinities of the Pruſſian colouring matter, its obſtinate adheſion to alkalis, and the means for obtaining it perfectly pure, Scheele, in a ſecond Memoir, examines into the nature of this ſubſtance,

ſtance, and its combinations with alkalis and metallic oxides. Although his experiments are numerous, and very accurate, Scheele does not prove in this Memoir that the Pruſſian colouring matter is a peculiar acid: On the contrary, he endeavours to ſhow, that it contains inflammable gas, ammoniac, and a carbonaceous principle. He acknowledges, however, that it renders a ſolution of ſoap turbid, and precipitates *hepars*, or alkaline ſulphures; and, in a letter to M. Crell, he calls it the colouring acid. We give this ſubſtance the name of the *Pruſſic acid*, and call its ſaline combinations *Pruſſiates* of potaſh, ſoda, ammoniac, &c. In a note by the tranſlator of Scheele, this acid is ſaid to be decompoſable by the acid of nitre; and a proceſs of M. Weſtrumb's is likewiſe given for obtaining Pruſſiate of potaſh very pure. It conſiſts in ſaturating cauſtic potaſh with colouring matter, digeſting it over white lead, to purify it from any hepatic gas which it may contain, mixing it with diſtilled vinegar, expoſing it to the ſun, as directed by M. Scopoli and Father Bercia, in order to precipitate the iron entirely, and adding to it two parts of rectified alcohol. The Pruſſiate of potaſh is then depoſited in bright lamellated flakes, waſhed with a new quantity of ſpirit of wine, dried, and diſſolved in diſtilled water. Dr Crell ſays, that Scheele ſent him, three months after M. Weſtrumb, an analagous proceſs for obtaining a teſt liquor, the purity of which might be depended upon, to aſcertain the preſence of iron on any occaſion.

The Pruſſic acid, or the colouring matter of Pruſſian blue, has likewiſe engaged M. Berthollet's attention, who has made ſtill later experiments upon it than any of the above-mentioned chemiſts. Though this able philoſo-

pher is not yet fully ſatisfied with his reſearches on this matter, they contain, however, a good many new facts and experiments, of ſuch conſequence as to render it proper for us to give here an extract from his Memoir, which he has obligingly communicated.

M. Berthollet firſt obſerves, that there are two kinds of Pruſſiate of iron; the one common Pruſſian blue, the other Pruſſian blue that has loſt a part of the acid which it poſſeſſes in its ordinary ſtate. The laſt of theſe he calls *Pruſſiate of iron with exceſs of oxide.* Pruſſian blue is in this ſtate, after being diſcoloured by an alkali. To ſeparate this exceſs of oxide, he employs the muriatic acid, which diſſolves it, leaving the Pruſſiate of iron in a neutral ſtate. He obſerves, with M. Landriani, that when alkali is digeſted hot on Pruſſian blue, the alkaline Pruſſiate then formed, diſſolves more oxide of iron than if the digeſtion had been performed with cold. Both of theſe chemiſts are of opinion, that an acid added to this triple combination combines with the exceſs of oxide of iron, and produces a precipitate of Pruſſian blue, juſt as when Pruſſiate of potaſh is mixed with a ſolution of iron. They ſay alſo, that heat cauſes this combination to yield a yellow Pruſſiate of iron, that is, with excèſs of oxide of iron. According to them, the acid added ſeizes the exceſs of oxide of iron, and the Pruſſian blue becoming then leſs ſoluble in the alkaline Pruſſiate, is of conſequence precipitated. When the Pruſſiate of potaſh, prepared by a moderate heat, has depoſited the Pruſſiate of iron with exceſs of oxide of iron, by ebullition, it may then be evaporated to dryneſs, diſſolved again in water and mixed with acids; but will not, by any of theſe expedients, be brought to depoſite Pruſſian blue. M. Berthollet

thollet ſays, that by evaporating the ſolution of Pruſſiate of potaſh thus purified, octahædral cryſtals are obtained with two pyramids truncated, ſo as to repreſent ſquare plates with their edges cut ſloping.

This chemiſt, on mixing a ſolution of theſe cryſtals with ſulphuric acid, and expoſing the mixture in a phial to the rays of the ſun, obſerved, that in a ſhort time a blue colouring matter began to appear, and was gradually precipitated till the mixture was entirely decompoſed. A mixture of the ſame kind, preſerved in a dark place, does not become blue, nor yield a precipitate, even though ſuffered to ſtand untouched for a number of months. A ſtrong heat produces abſolutely the ſame effect. From theſe experiments, M. Berthollet ſhows how inaccurate the principles on which the proceſſes recommended for purifying alkaline Pruſſiates were founded. For, ſays he, inſtead of purifying them of a portion of Pruſſian blue, which chemiſts pretended to be only accidentally mixed in them, they decompoſed moſt part of the matter which they attempted to purify. As Pruſſiate of potaſh is a triple ſalt, the Pruſſic acid has but a very faint diſpoſition to adhere with potaſh, and may be ſeparated from it by any other acid. When the extraneous acid combines with the potaſh, one part of the Pruſſic acid combines with the oxide of iron, to form Pruſſian blue, and the other is either volatilized in the the ſtate of acid, or reduced to its principles.

The iron precipitated by alkaline Pruſſiates retains, according to M. Berthollet, no ſmall portion of thoſe ſalts; by repeating waſhing, it may be purified of them: theſe lixiviums contain alkalis combined with a ſmall portion of Pruſſic acid; and the Pruſſiates with exceſs of

alkali

alkali are not ſeparated till after the exceſs of acid contained in the ſolution of iron is carried off by the firſt waſhings; for the latter waſhings precipitate the iron in the ſtate of blue from its ſolutions, which the firſt do not.

The only diſcernible difference which he has found between Pruſſiate of potaſh and Pruſſiate of ſoda is, that the latter cryſtallizes differently from the former. Mineral acids diſengage the Pruſſic acid, which is in part fixed in the Pruſſian blue that is precipitated. This led Scheele to think of another combination, from which he might, with greater facility, obtain this acid pure, on which M. Berthollet has made ſome obſervations. This proceſs, as we have already mentioned, conſiſts in boiling red oxide of mercury with Pruſſian blue and diſtilled water. The Pruſſic acid then forſakes the oxide of iron, to unite with the oxide of mercury, with which it has a ſtronger affinity, and forms a ſoluble ſalt, which cryſtallizes in tetrahædral priſms, terminating in quadrangular pyramids, the ſides of which correſpond to thoſe of the priſms. To this lixivium, after filtrating it, iron and concentrated ſulphuric acid are to be added; the iron unites with the oxigene of the mercury, and afterwards combines with the ſulphuric acid; the mercury is precipitated in a metallic ſtate, as appears from its luſtre. Scheele next diſtilled this mixture by a moderate heat, that he might volatilize only the Pruſſic acid; but he obſerved, that, however moderate the heat which he employed, the Pruſſic was always mixed with a little ſulphuric acid. To prevent this, he added to the mixture a certain quantity of chalk, to fix the ſulphuric acid. Concerning this addition, M. Berthollet has obſerved, that, as Scheele

has not ſpecified the quantity, this operation might very eaſily miſcarry, if the chalk were ever ſo little above what is ſufficient to ſaturate the ſulphuric acid: for calcareous Pruſſiate muſt then be formed, which, by the law of double affinities, would decompoſe the ſulphate of iron.

M. Berthollet has obſerved, that the ſulphuric acid diſengages but a ſmall portion of acid from Pruſſiate of mercury; and that it combines with the greateſt part of that ſalt, without decompoſing it, thus forming a triple ſalt, which cryſtallizes in ſmall needles. According to his experiments, the muriatic acid diſengages more of the acid of Pruſſiate of mercury than the ſulphuric acid does; forming, like it, a triple ſalt cryſtallizable in needles, and much more ſoluble than corroſive mercurial muriate. Alkalis and lime cauſe this triple ſalt to yield a white precipitate. M. Berthollet proves, that alkaline Pruſſiates do not precipitate barytes from its ſolutions, as Bergman thought, but join with the ſolution to form triple ſalts: he ſhows that they precipitate aluminous earth. The precipitate which they form with this ſubſtance ſuffers no alteration from the ſulphuric acid; but when digeſted with ſulphate of iron, it forms Pruſſian blue.

The Pruſſic acid decompoſes the oxigenated muriatic acid, and by abſorbing its oxigene, becomes odorous. In this ſtate it does not ſeem to have any great tendency to unite with alkaline ſubſtances; for they ſcarce render its ſmell weaker. It no longer cauſes ſolutions of iron to yield a blue, but a green precipitate. The contact of the rays of the ſun renders it blue again; iron and ſulphureous acid produce the ſame ef-

fect upon it. The ſame phænomena appear when oxigenated muriatic acid, ſulphate of iron, and Pruſſiate of pótaſh, are mixed together. M. Berthollet concludes from this, that Pruſſian blue is liable to no alteration, either from light or from the ſulpureous acid, and that it owes its green colour, ſolubility in acids, &c. to its having abſorbed oxigene.

If the Pruſſic acid be ſuperſaturated with oxigenated muriatic acid, and after that expoſed to the rays of light, it aſſumes new characteriſtic properties. It no longer combines either with oxide of iron, or with water; but is found precipitated to the bottom of either of theſe liquors, in the form of oil, with an aromatic ſmell. If more oxigene be added to it when in this ſtate, and it be now let expoſed to the ſun, it cryſtallizes in ſmall white needles. This acid, thus oxigenated, is reduced to vapours by a moderate heat; theſe vapours are neither ſoluble in water nor combuſtible. M. Berthollet has not yet been able to determine what paſſes in this operation. Is the Pruſſic acid ſimply united with oxigene, without ſuffering any alteration? or is there one of its principles burnt? I am rather inclined to agree with him in adopting the laſt of theſe ideas: For though oxigene appears to adhere but feebly to the Pruſſic acid, yet the Pruſſic acid can no longer be reſtored to its originial ſtate, after being treated in this manner with the oxigenated muriatic acid.

The Pruſſic acid prepared for forming a green precipitate with iron, by means of the oxigenated muriatic acid, forms ammoniac whenever lime or an alkali is mixed with it. Though an acid be poured into this laſt mixture, yet it does not regain the peculiar odour of the

Pruſſic acid; from which M. Berthollet concludes it to have been deſtroyed by the mixture of the alkaline, or calcareous ſubſtance. Although the potaſh employed were perfectly pure, yet an acid poured in after it, produces an effervescence, and diſengages carbonic acid.

From all theſe experiments, M. Berthollet concludes, that azote, hydrogene, and the pure coaly principle, combined in proportions, and condenſed to a degree ſtill unknown, form what is called the *Pruſſic acid*. The knowledge of this compoſition enables us to underſtand how the Pruſſic acid comes to be formed in animal matters, in certain vegetable ſubſtances, and in ammoniacal muriate contaminated with charcoal. It explains likewiſe the reaſon why this acid is ſo combuſtible, and detonizes with ſuch force with various nitrates, why it affords ammoniacal carbonate by diſtillation, and why the ſame ſalt is formed in it on the addition of oxigenated muriatic acid. M. Berthollet doubts if this ſingular combination contains oxigene. At leaſt, ſays he, if the Pruſſic acid *do* contain oxigene, it contains ſo very little, that the carbonaceous matter is not entirely reduced by it to carbonic acid; for Pruſſian blue affords, by diſtillation, a good deal of carbonated hydrogenous gas.

Such are the facts diſcovered by M. Berthollet. By aſcertaining the nature of the colouring matter of Pruſſian blue, he has proved it not to be a genuine acid, however it may act as an acid in all its combinations. M. Veſtrumb and M. Haſſenfratz have found in Pruſſian blue a little phoſphoric acid. But the laſt of theſe gentlemen ſhows that acid not to be eſſential to its nature.

ture. M. Vaquelin and I have lately diſcovered, that the Pruſſic acid is obtained by diſtilling the urinary calculus, and by treating many vegetable and animal ſubſtances with the nitric acid.

Sulphate of iron very eaſily decompoſes nitre. The decompoſition is partly owing to the ſulphuric acid, which by combining with the alkali of the nitre, expels the nitric acid; but it is likewiſe owing in a great meaſure to the re-action of the iron on the laſt mentioned acid. If the ſulphate of iron employed to decompoſe nitre be ſcarcely dry, a large quantity of nitrous acid is then obtained, very red and fuming: the reſidue, on being lixiviated, affords ſulphate of potaſh, fixed alkali, and red oxide of iron, remaining on the filters. But if the ſulphate of iron have been well calcined, and the nitre melted, the product obtained will then be very ſcanty. This product conſiſts of two liquors; one of which being of a dark colour, almoſt black indeed, ſwims on the ſurface of the other, which is red and ponderous, like oil above water. Accordingly, M. Baumé conſiders this liquor as a kind of oil. There afterwards paſſes into the neck of the retort a white ſaline maſs, which attracts the moiſture of the atmoſphere, and is ſpeedily diſſolved in water with heat, exhaling at the time a ſtrong ſmell of ſpirit of nitre, and very thick red vapours. This ſolution, when ſaturated with potaſh, affords ſulphate of potaſh. The white maſs is therefore nothing but ſulphuric acid, rendered concrete by a portion of nitrous gas.

There appears to be no difference between the heavy liquor in the balloon, and ſpirit of nitre obtained in Glauber's way. But the light liquor that ſwims above,

on being mixed with ſulphuric acid, produces a lively effervescence, and even a dangerous exploſion. Almoſt the whole of the nitrous acid is diſſipated, and the ſulphuric acid takes a concrete cryſtalline form. Bucquet, who communicated this diſcovery to the Academy, had at firſt obſerved, that this concrete acid, obtained by diſtillation, exhales red nitrous vapours when diſſolved in water. He inferred, that the ſolidity of the acid muſt be owing to its containing nitrous gas. But to determine this with greater certainty, he attempted to mix the blackiſh brown nitrous acid, which ſwims above the red, with ſulphuric acid highly concentrated. But at the very inſtant of the mixture, ſo rapid a motion took place, that the ſpirit of nitre poured on the ſulphuric acid was expelled with noiſe to a great diſtance; and the perſon who made the mixture was covered all over with ſulphuric acid; and there immediately appeared on his countenance a great many red inflamed pimples, which ſuppurated like the ſmall-pox. The ſulphuric acid became ſoon after concrete, preciſely like that obtained by diſtillation, of which we have given the hiſtory. From this fact, it appears, that this acid may be rendered concrete, as well by nitrous as by ſulphureous gas.

The reſidue remaining after the diſtillation of nitre by ſulphate of iron calcined to redneſs, is nothing but ſcoriæ of iron, from which but very little ſulphate of potaſh can be extracted by waſhing.

The ſolution of ſulphate of iron ſuffers no alteration from hydrogenous gas. But though the baſe of this claſtic fluid appears to have leſs affinity than iron with oxigene, as has been ſhown in the hiſtory of the decompoſition

poſition of water; yet M. Monnet has obſerved, that hepatic gas communicates to ſulphuric mother-water the property of affording cryſtals: And Dr. Prieſtley has reduced brown oxides of iron by the contact of hydrogenous gas. Theſe facts do not contradict our doctrine: they rather confirm it. In fact, iron may be deprived of whatever oxigene it contains above the proportion of 0,28 by the action of hydrogene; but this proportion it obſtinately retains, however attacked by that principle. Such is the reaſon why, in theſe inſtances of reduction, nothing is ever obtained but a black oxide, or martial Æthiops, and why iron oxidated by water is always black.

Alkaline ſulphures precipitate ſulphate of iron with a blackiſh colour. This precipitate is a kind of martial pyrites, or ſulphure of iron.

The nitric acid is rapidly decompoſed by iron, which diſengages from it a good deal of nitrous gas, eſpecially if the acid employed be concentrated, and the iron in a ſtate of diviſion. The metal is ſpeedily calcined by the oxigene which it attracts from the acid of nitre; the ſolution is of a brown red colour; at the end of a certain time it is found to have depoſited oxide of iron, eſpecially if it have been expoſed to the contact of air. On immerſing into it a new quantity of iron, the acid, as has been obſerved by Stahl, diſſolves it, and the oxide of iron, which it held in ſolution, is inſtantaneouſly precipitated. Yet by employing weak nitric acid and iron in ſmall pieces, a more permanent ſolution may be obtained, in which the metal adheres with more obſtinacy to the acid. This laſt combination is greeniſh, and ſometimes of a bright yellow colour. Both theſe

ſolutions, when evaporated, become turbid, and depoſite a brown red martial ochre. But if the latter be highly concentrated, inſtead of affording cryſtals, it takes the conſiſtency of a reddiſh jelly, in part ſoluble in water; the greateſt part, however, being precipitated on ſuch an occaſion. On continuing to heat nitrate of iron, it gives out a good deal of red vapours; and the magma, becoming dry, affords a brick-coloured oxide. This magma, when diſtilled in a retort, affords a ſmall quantity of fuming nitrous acid, a good deal of nitrous gas, and ſome azotic gas. There can be no vital air obtained from it, becauſe the iron retains all the oxigene of the acid. The oxide which remains after the diſtillation of nitrate of iron is of a lively red colour, and would make a fine colouring matter for painters, &c. The nitrous ſolution of iron, however highly ſaturated, has never, on any occaſion, appeared to me liable to be precipitated by diſtilled water. The alkalis decompoſe it with phænomena diverſified according to their different natures. Cauſtic potaſh makes it yield a bright brown precipitate: the mixture aſſumes very ſpeedily a blackiſh brown colour, much deeper than that of the former ſolution. The cauſe of this phænomena is, that a portion, though a very ſmall one indeed, of the precipitate is diſſolved by the alkali. Carbonate of potaſh ſeparates from it a yellowiſh oxide, which very ſoon takes a beautiful orange red colour. If this mixture be ſtirred in proportion as the efferveſcence takes place, the precipitate is again diſſolved in much greater abundance than in that which is produced by cauſtic potaſh. M. Monnet has accurately obſerved this phænomenon, and he aſcribes it with good reaſon to the gas, which is diſengaged.

diſengaged. This ſolution of iron by fixed alkali bears the name of *Stahl's alkaline martial tincture.* Its colour is a very beautiful red. M. Baumé adviſes to prepare it with a nitrous ſolution of iron, containing but a ſmall portion of the metal. Stahl, again, recommended an highly ſaturated ſolution. M. Monnet has obſerved, that a yellow ſolution affords a copious precipitate, which is ſcarce diſſolved again in alkali, and does not colour it like martial tincture; whereas a very red ſolution inſtantaneouſly forms a martial tincture with the ſame alkali. Stahl's martial tincture loſes its colour in a certain time, and depoſites the oxide of iron which it contains. It may be decompoſed with the help of an acid. The acid of nitre ſeparates from it a red brick-coloured oxide, which is ſoluble in acids, and is called *Stahl's aperient ſaffron of Mars.* Pure or cauſtic ammoniac cauſes the nitric ſolution of iron to yield an almoſt blackiſh deep green precipitate. Ammoniacal carbonate diſſolves again the iron which it ſeparates from the acid, and takes a red colour ſtill more lively than that of Stahl's tincture. This ſolution of iron by ammoniacal carbonate, might be of great uſe in caſes in which there is need both of a powerful tonic and an active diſcuſſive.

I have never been able to obtain more than a very ſmall quantity of genuine Pruſſian blue from the red, ſaturated, nitric ſolution of iron, by alkali ſaturated with the colouring matter of that compoſition. I could never obtain any thing but a blackiſh precipitate, liable to be again diſſolved by the muriatic acid: the liquor, on this laſt event, aſſumed a green colour.

M. Maret, ſecretary to the Academy of Dijon, has ſent to the Royal Society of Medicine, a proceſs for making

king *martial Æthiops* very quickly. It conſiſts in precipitating the nitric ſolution of iron by cauſtic ammoniac, and in waſhing and drying the precipitate without loſs of time. M. d'Arcet, who was employed by the Society to examine M. Maret's proceſs, did not uniformly obtain the ſame reſult. In my Memoirs on Precipitates of Iron, I have determined in what caſes M. Maret's proceſs muſt ſucceed, and when it is likely to fail. To obtain this Æthiops, it is requiſite, 1. That the ſolution of iron have been lately formed, and that very ſlowly, of weak nitric acid, and iron ſomewhat divided, both cold. 2. That the ammoniac be recently prepared, very cauſtic, and, above all, have loſt, by ſtanding undiſturbed for ſome time, the ſmall portion of calcareous earth, and blackiſh combuſtible matters, which it uſually carries up from the ſal ammoniac and lime, if it be not extracted in Woulfe's apparatus. 3. That the precipitate be inſtantly ſeparated from the liquor, and ſpeedily dried in cloſe veſſels. Even when all theſe precautions are carefully taken, the precipitate is ſometimes not very black, but rather of a light brown colour. It riſes in ſcales, the under ſurface of which is blackiſh; a circumſtance which proves, that the contact of air ſlightly ruſts its upper ſurface. I have obtained a more beautiful and permanent *Æthiops*, by precipitating muriatic and acetous ſolutions of iron with fixed alkali and cauſtic ammoniac; waſhing theſe precipitates ſufficiently, and then drying them ſpeedily in cloſe veſſels. Yet I am of opinion, that theſe *Æthiops*, however pure they may be ſuppoſed to be, ſtill retain a ſmall portion of their precipitants and firſt ſolvents; as has been obſerved by M. Bayen of the precipitates of mercury; and they cannot therefore be employed in

medicine

medicine with ſo much certainty as thoſe which I have above mentioned. M. d'Arcet, in his Report to the Royal Society of Medicine concerning M. Maret's proceſs, has communicated a proceſs of M. Crohare's, for making *martial Æthiops*. This apothecary, who is known by a number of judicious chemical operations, prepares *martial Æthiops* by boiling water acidulated with a little nitric acid, upon iron filings. The metal is immediately ſlightly oxidated, and affords a good deal of black oxide, or *martial Æthiops*. But in my opinion, M. Joſſe's proceſs is preferable to all of theſe; it is eaſily performed, and is attended with no danger.

As iron is often uſed in procuring nitrous gas, it cannot be improper to obſerve here, that the nature of this gas is never preciſely the ſame on two occaſions; it varies amazingly, according as the circumſtances of the ſolution are diverſified, as the acid contains more or leſs azote and oxigene, as the iron is more or leſs diſpoſed to abſorb oxigene, as the temperature of the matters is hotter or colder, &c. Gas prepared by this proceſs generally contains more or leſs azote; for as iron abſorbs a greater proportion of oxigene than moſt other bodies, and abſorbs different quantities of it, according as it is more or leſs completely in a metallic ſtate, the effects of nitrous gas diſengaged by this metal are therefore more or leſs uncertain in eudiometric experiments. This truth, which is applicable to all bodies that ſeparate nitrous gas from the acid of nitre, ſhows how little the eſſays of eudiometers with nitrous gas are to be depended upon. Alkaline ſulphures are therefore

fore greatly preferable as teſts for determining the purity of air.

The muriatic acid diluted in water diſſolves iron rapidly. A large quantity of hydrogenous gas is diſengaged from this ſolution, the production of which muſt be owing to the decompoſition of the water, in the ſame manner as when the metal is diſſolved in the ſulphuric acid. The hydrogenous gas produced by the action of iron on the muriatic acid, was formerly thought to be different in nature from that which is diſengaged from the ſulphuric ſolution of iron. This elaſtic fluid was then thought to be one of the principles of the muriatic acid. But ſince the diſcovery of the decompoſition of water by iron, it has been proved, that the water, and not the muriatic acid, the nature of which is ſtill unknown, gives riſe to the hydrogenous gas diſengaged from the muriatic ſolution of iron; for the acid remains undiminiſhed and unaltered after the exhalation of this gas, and the ſame quantity of alkali is neceſſary to ſaturate it which it would have been required before. This ſolution of iron by the muriatic acid produces a conſiderable heat; which continues to be felt till the acid be ſaturated: a portion of the iron is precipitated in real *Æthiops*, in this as well as in all its other ſolutions. When filtrated, it is of a green colour, inclining to yellow: It is much more permanent than either of the two former; when incloſed in a phial properly ſtopped, it depoſites no oxide. I have kept by me ſome of it for eight years; in all which time it has depoſited nothing but a very light pale yellow duſt. But, again, when it is left expoſed to the air, it depoſites in a few weeks almoſt all the iron that it contains;

and

and the more it has been brought into contact with air, the brighter is the colour of the precipitate. It is at preſent known as a certain fact, that this precipitation, which is in the ſame manner produced in all the other ſolutions of iron, is owing to the metal abſorbing the oxigene of the atmoſphere; as I conjectured, and ſuggeſted to the public in the year 1777. (See my *Memoirs on Chemiſtry.*)

Stahl announced to the world, that in the combination of iron with the muriatic acid, the muriatic acquired the characteriſtic properties of the nitric acid. But this fact has not been obſerved by any other chemiſt. It appears that Stahl attended only to the yellow colour of this ſolution, and the ſmell which it diffuſes; a ſmell in fact but little different from that of ſpirit of ſalt, and much the ſame as that of the oxigenated muriatic acid.

The ſolution of iron by the muriatic acid does not cryſtallize regularly when evaporated. M. Monnet has obſerved, that if left to cool, when its conſiſtency is that of a ſyrup, it forms a kind of magma, in which flat needled cryſtals are obſerved, which are liable to deliquiate. This magma melts by a very moderate heat; when a ſtronger heat is applied, it is decompoſed, but not ſo eaſily as nitrate of iron; and when dry, it takes the colour of ruſt. There is diſengaged from it a portion of muriatic acid, which may be obtained by diſtillation; and which, as has been remarked by Brandt, carries off with it a little oxide of iron.

The Duke d'Ayen, in four excellent Memoirs on the combinations of iron with acids, which he has given the Academy, has entered into a minute examination of

of what paſſes when muriate of iron is decompoſed in a retort. He obtained from this operation very ſingular products: He firſt obtained, by a moderate heat, a phlegm ſlightly acidulated: the muriatic acid was then concentrated; and its gas, though much more volatile than water, was in part fixed by the iron. By a much ſtronger heat, a part of the acid was volatilized with a little iron, and ſome cryſtals, not diſpoſed to deliquiate, were formed in the balloon. At the ſame time, there were ſublimed to the upper part of the retort, a number of very tranſparent cryſtals, reſembling razor-blades, which decompoſed the light like the moſt beauful priſms, diſplaying very beautiful ſhades of red, yellow, green, and blue. There remained at the bottom of the retort a ſtiptic, deliquiating ſalt, of a brilliant colour and a foliated form, preciſely like that ſpecies of talc in large plates, which is improperly called *Muſcovy glaſs*. This laſt ſalt, when expoſed to a violent heat in a ſtone retort, was decompoſed, and afforded a ſublimated product of a ſtill more ſurpriſing nature than any of the former products. It was an opaque matter, truly metallic in its nature, and when examined by the microſcope, it exhibited regular cryſtals, or ſections of hexagonal priſms, which the Duke d'Ayen compares to the ſquare pieces of wood uſed in flooring rooms. Thoſe cryſtals were as brilliant as the beſt poliſhed ſteel, and equally ſubject to the attraction of the loadſtone; this was iron partly reduced and ſublimated *. Art ſeems, in this inſtance, to effect an imitation of

* I have in my cabinet a black iron ore, with ſmall and very brilliant laminæ, half a line in breadth, the form of which nearly reſembles that

of nature, which ſublimes black oxides of iron by the fire of volcanoes, in the form of bright poliſhed plates like Steel. Such at leaſt appears to be the origin of the ſpecular iron of Mont d'Or and of Volvic; which, according to the accurate obſervations of M. de l'Arbre, phyſician at Riom, is always found in the chinks of lavas.

From theſe particulars, it appears what ſingular phænomena the ſcience of chemiſtry offers to our obſervation, and what valuable diſcoveries it promiſes to ſuch as ſhall purſue a train of experiments with the accuracy and perſeverance of the Duke d' Ayen. Let it not eſcape us, that this reduction of iron favours the doctrine of gaſes, and that ſimilar products might perhaps be obtained by the ſame proceſs from many other ſolutions of metals.

The muriatic ſolution of iron is decompoſed by lime and alkalis, like all martial ſolutions; but theſe precipitates are not ſo much altered, and may be very eaſily reduced, eſpecially ſuch as are produced by cauſtic alkalis. I have already obſerved, that this combination affords by precipitation the pureſt *Æthiops*, or black oxide of iron, that can poſſibly be obtained. Alkaline ſulphures, ſulphurated hydrogenous gas, and aſtringents, decompoſe this ſolution as well as the other two: laſtly, Pruſſian alkalis, or alkaline Pruſſiates, cauſe it to yield a very beautiful blue precipitate.

Water

that of the cryſtals obtained by the Duke d'Ayen. They are very thin ſmall ſcales, of a very ſparkling grey iron-colour, diſpoſed ſlopewiſe, ſo as to interſect each other in all directions, and diſperſed in a reddiſh opaque quartz, or a kind of coarſe jaſper. This beautiful ſpecimen comes from Lorraine. The iron of Framont is of the ſame nature. F.

Water impregnated with carbonic acid eaſily diſſolves iron: all that is neceſſary in order to accompliſh this combination is to put iron filings into the acidulated liquid, and to leave the mixture to digeſt during a few hours. This liquor, after being filtrated, has a pungent, and ſomewhat ſtiptic taſte. Meſſrs Lane and Rouelle have obſerved the carbonic acid to poſſeſs this property. Bergman calls this combination *aerated iron*, and ſays, that when expoſed to the open air it acquires a rainbow-coloured pellicle; that it is decompoſable by pure alkalis: but that alkalis ſaturated with carbonic acid produce not the ſame effect upon it. This ſolution gives a green tinge to ſyrup of voilets, and affords with calcareous Pruſſiate a very brilliant Pruſſian blue. When expoſed to the air, or heated, it precipitates brown oxide of iron. The name which we give to this combination is *carbonate of iron*. Iron has a ſtrong tendency to combine with the carbonic acid. In nature we often find it in this ſtate. Muddy iron ores and ſparry iron appear to conſiſt moſtly of this combination. Ferruginous mineral waters often contain iron in the ſtate of carbonate of iron. This ſalt, when ſeparated from the water, and dried, is ſcarce ſoluble in that fluid. But it diſſolves plentifully in liquid carbonic acid; ſubſiding, however, in a precipitate when the acid is volatilized. We know not in what manner the fluoric and the boracic acids act upon iron.

This metal very readily decompoſes ſulphuric ſalts, particularly ſulphate of potaſh or ſoda. I have treated theſe ſalts with iron in a crucible, and have found them reduced by ſuch treatment to the ſtate of ſulphures. The lixivium of a ſulphure of this kind is of a very deep

green colour. A few drops of acid very ſpeedily deſtroy the colour of this metallic tincture. The greateſt part of the iron, oxidated by the oxigene of the ſulphuric acid, remains undiſſolved in the water of the lixivium; and acids diſengage from it a large quantity of ſulphurated hydrogenous gas.

Iron cauſes nitre to detonize. On throwing into a red-hot crucible a mixture conſiſting of equal parts of iron filings and dry nitre, in a certain time a very rapid motion is excited, and a great many bright ſparks fly out of the crucible. When the detonation is over, the crucible contains a reddiſh oxide of iron, of which a ſmall part is combined with the alkali; when this matter is waſhed, the water diſſolves the alkali, and the oxide of iron remains on the filter. This oxide was formerly called *Zwelfer's ſaffron of Mars.* It is of a reddiſh yellow colour, and is ſcarce ſoluble in acids. The alkali ſeparated from it by waſhing is cauſtic, according to moſt chemiſts; for it is generally thought that metallic oxides act like pure lime on this ſalt, thus ſaturated with carbonic acid *.

Iron eaſily decompoſes ammoniacal muriate. Two drachms of iron filings, triturated with a drachm of this ſalt, give out ammoniac gas. Bucquet, who diſtilled this mixture in a pneumato-chemical apparatus with mercury, obtained from it fifty-four cubic inches of acriform

* It is to be obſerved, that ſince Black's Theory, concerning the cauſticity of lime and alkalis, has been received, the proper experiments have not yet been made to determine whether metallic oxides and lime, properly ſo called, agree in their phænomena in this reſpect. And, till experiment determine, we can ſay nothing certain on this head. A.

fluid; one half of which was ammoniac gas, and the other half hydrogenous gas. Four ounces of the ſame filings, with two ounces of ammoniacal muriate, afford, when diſtilled in a retort with a common receiver, about two drachms of liquid ammoniac, impregnated with a little iron, which it ſoon depoſites in the ſtate of oxide of iron. The reſidue of theſe operations is muriate of iron. What occaſions the decompoſition of ammoniacal muriate by iron is, that the metal eagerly combines with muriatic acid: a proof of which is the diſengagement of hydrogenous gas, obſerved to take place during the operation. In pharmacy, there is a medicine prepared of ammoniacal muriate and iron, which is called *martial flowers of ſal ammoniac*, or *ens martis*. A pound of ammoniacal muriate in powder is mixed with an ounce of iron filings: this mixture is expoſed in an earthen pot covered with another veſſel of the ſame kind to a fire ſufficient to make the under-part of the apparatus red-hot. In five or ſix hours, there is a yellow matter ſublimated, which is to be preſerved in a phial; this matter is the *martial flowers*. This ſubſtance conſiſts chiefly of ſublimated ammoniacal muriate, with a little oxide of iron. As the metal very readily decompoſes this ſalt, only a very ſmall quantity of it muſt be employed, in order that the greateſt part of the ſalt may be ſublimed in its natural ſtate. That portion of the oxide of iron which is volatilized, communicates a yellow colour to the ammoniacal muriate, which is at the ſame time ſublimated.

Oxide of iron decompoſes this ſalt better than the metal itſelf; for it diſengages the ammoniac without heat. That which is obtained by diſtillation is very fluid, and ſufficiently cauſtic. I have obtained ammoniac, which

which gave a ſlight effervescence with acids, by diſtilling ammoniacal muriate with half its weight of *aperitive ſaffron of Mars*, or oxide of iron, prepared with acceſs of air, and of conſequence containing carbonic acid. In this inſtance, the carbonic acid diſengaged from the iron combined with the ammoniac, and ſo rendered it effervescent.

Iron is altered in its colour by hydrogenous gas; but the alteration which it ſuffers has not been yet ſufficiently examined. Black oxide of iron is not decompoſed by this gas; but the brown or the red oxides eaſily are, and they then paſs into the ſtate of black oxide; for hydrogene robs them of all the oxigene they contain, more than what is requiſite to maintain them in the ſtate of black oxide. Sulphur combines rapidly with iron. A mixture, conſiſting of iron filings and ſulphur in powder, and moiſtened with a little water, becomes hot in a few hours. It then ſwells, acquires conſiſtency, abſorbs the water, burſts with a diſcernible crackling, and exhales a good deal of aqueous vapour, accompanied with a fœtid odour, very like that of ſulphurated hydrogenous gas. When the mixture is a large maſs, it takes fire in the ſpace of four and twenty or thirty hours, and as ſoon as ever the aqueous vapours ceaſe to ariſe from it. When the ſubſtances have nearly ceaſed to act on each other, the heat rapidly increaſes, and inflammation takes place. The ſmell then becomes much ſtronger; it ſeems to be owing to the hydrogenous gas produced by the action of the ſulphur and iron on the water. This ſmell is mixed with another, that of alkaline ſulphures and pure hydrogenous gas;

the inflammation obſerved in this experiment is, no doubt, owing to a copious diſengagement of hydrogenous gas; for the flame is more lively than that of ſulphur. It riſes a foot high, according to M. Baumé's account, who obſerved this phænomenon on a mixture, conſiſting of an hundred pounds of iron filings, and as much ſulphur in powder: it laſts only for two or three minutes; the mixture continued red and burning for forty. M. Baumé explains this inflammation into the diſengagement of the phlogiſton of the ſulphur into the ſtate of free fire. Lemery, the father, has given the name of artificial volcano to this experiment. He imagined the fires which kindle in the interior parts of our globe, and by forcing their way to the ſurface, produce earthquakes and volcanoes, to ariſe from a ſimilar combuſtion of pyrites piled on each other, and moiſtened by water. In his opinion, theſe awful phænomena might be imitated, by burying in the earth a mixture of ſulphur in powder and iron filings, reduced to a paſte with water, and covering it over with earth preſſed cloſely down upon it. This experiment did not ſucceed with Bucquet, who repeated it with the greateſt exactneſs. Dr Prieſtley ſeemed to ſhow the reaſon why it failed. That philoſopher obſerved, that the moiſtened mixture of ſulphur and iron abſorbed a certain quantity of air, which might be thought neceſſary to its inflammation. But, notwithſtanding this, the inflammation takes place without the contact of air. It appears, in fact, that the iron being very much divided, re-acts on the fluid, and ſeizes its oxigene, by which it is calcined, and diſengages the hydrogenous gas, which takes an elaſtic form by means of the heat ſeparated from the water. This gas

alſo

alſo diſſolves a portion of the ſulphur, and thus becomes ſulphurated hydrogenous gas.

There is a ſtrong analogy between this combination of iron and ſulphur by the humid way, and the efflorescence of *pyrites;* which, when they are moiſtened by water, produce ſulphurated hydrogenous gas.

Sulphur combines very eaſily with iron by fuſion; the reſult is a ſulphure of iron, or pyrites arranged in needles. As in this caſe the ſulphur increaſes greatly the fuſibility of iron, the metal may be inſtantaneouſly melted with the help of this combuſtible body. In order to this, a ſmall bar of iron, heated to whiteneſs, may be applied to a roll of ſulphur, and the melted matter which runs from them received into water. It will be found in the fluid in brittle blackiſh globules, reſembling *pyrites*, and, like them, in the form of ſmall ſlender concentric pyramids.

Iron with arſenic affords a brittle mixture, which is but very little known.

This metal appears to exiſt in many iron ores; and it is in conſequence of being intermixed with it that iron is brittle when hot.

With cobalt, iron forms a metallic mixture, with ſmall cloſe grains, hard, and not eaſily broken.

It does not appear capable of combining with biſmuth.

In combination with antimony, it forms a brittle alloy with ſmall facets, which yields but very little to the hammer. Iron has more affinity than antimony with ſulphur; and is of conſequence capable of decompoſing ſulphure of antimony. To effect this decompoſition, make five ounces of the points of horſe-ſhoe nails red-

hot in a crucible; throw upon them a pound of pulverized ſulphure of antimony; and apply ſpeedily to this mixture a heat ſufficiently ſtrong to melt it: when it is pretty well melted, add an ounce of nitre in powder, to promote, by a thorough fuſion, the ſeparation of the ſcoriæ from the antimony; let the mixture be now left to cool, and the antimony will be found by itſelf not impregnated with any iron. If the mixture employed conſiſt of one part of iron, with two of ſulphure of antimony, the antimony will be alloyed with iron. The ſcoriæ which are found above antimony alloyed with iron, and prepared with nitre and tartar, are of a yellowiſh colour like amber, which they owe to the iron contained in them. Stahl has, on this account, called them *ſuccinated ſcoriæ*. He directs to reduce them to powder; then boil the powder in water, which carries off the moſt ſubtle part of it; decant off the liquor; filtrate it; and detonize the powder remaining on the filter three times with nitre; then waſh and dry it: and the matter thus prepared is Stahl's *aperitive ſaffron of antimoniated Mars*.

It is ſtill uncertain whether zinc be capable of entering into union with iron. Malouin, in his Memoir on Zinc (*Academy*, 1742), has ſhown, that this ſemi-metal may be applied like tin to the ſurface of a piece of iron, ſo as to ſecure it from the contact of air; a circumſtance which ſhows, that theſe two metallic matters are capable of entering into combination with one another.

It appears that nickel enters into a very intimate union with iron; for, as Bergman has ſhown, theſe two metallic ſubſtances can never be entirely ſeparated.

Mercury

Mercury can contract no union with iron in its metallic ſtate. Ineffectual attempts have been made to produce a direct combination of theſe two ſubſtances; but their oxides have been combined. Navier has obſerved, that a ſnowy white precipitate may be obtained by mixing together a ſolution of iron and a ſolution of mercury, both made by the ſulphuric acid; and on evaporating this mixture, ſmall flat cryſtals are formed in it, very thin, and reſembling the boracic acid. Navier is convinced that theſe cryſtals are a combination of iron with mercury.

Lead cannot enter into union with iron.

It appears that iron and tin may be combined by fuſion. That art which conſiſts in coating the ſurface of iron with tin, or preparing white iron, ſhows this combination to be poſſible. The ſurface of iron to be tinned muſt be ſmooth and ſparkling. For this end, it is ſometimes cleared with an acid, ſometimes filed, and ſometimes coated with ſal ammoniac: when prepared in this manner, it is immerſed vertically into a veſſel full of melted tin; its poſition in the veſſel is repeatedly changed, in order to bring it more completely in contact with the tin; and when it is thought to be ſufficiently tinned, it is taken out and rubbed with ſaw-duſt or bran, to clear it from the tallow or pitch with which the ſurface of the melted tin is covered, and which of conſequence ſticks to the ſurface of the tinned iron. If the iron ſubjected to this proceſs be in very thin plates, the tin will not barely adhere to its ſurface, but penetrate through it, and combine with all its parts: and on cutting or breaking it, the ſame white colour will appear in the midſt as on the ſurface of the plate: From which

it appears, that white iron, properly prepared, is actually a chemical combination. Beſides, it is more malleable than iron, and is wrought into veſſels of a form which it would be impoſſible to make the pure metal take with the hammer.

We have ſeen, in the beginning of this chapter, that iron eaſily abſorbs carbone by heat, forming, by its union with that combuſtible body, caſt iron and ſteel; with this difference between theſe two compounds, that in the former oxigene is contained, but not in the latter. In both, the quantity of the iron is much above that of the carbone. Scheele, who has applied chemical analyſis to ſo many happy purpoſes, found, on inveſtigating by this method the nature of *plumbago*, a ſpecies of mineral, the rank and character of which naturaliſts were long at a loſs to determine, that it is nothing but a natural combination, conſiſting of a large quantity of carbone, with a very ſmall proportion of iron.

Plumbago has been long confounded with *molybdena**. Pott was the firſt who proved that neither of theſe ſubſtances contains lead, as they were anciently thought to do. The names beſtowed on *molybdena* and *plumbago* were formed to perpetuate the error. They were both indifferently called *lead ore*, *Engliſh pencil*, *marine lead*, *black ceruſe*, *painter's mica*, *lead pencil*, *falſe galena*, *talc*, *blende*, *potelot*.

Native *carbure of iron* (a name which, as expreſſive of the nature of the compound, we have ſubſtituted inſtead of

* It is now agreed, that the ſubſtance called *molybdena* is the oxide of a certain acidifiable ſemi-metal. Its hiſtory has been given among the ſemi-metals. F.

of *plumbago)* is found in mountains, frequently among beds of quartz, feldt-ſpar, clay, or chalk, in the form of irregular round lumps, or balls, like the teſticles of animals of various ſizes; the largeſt weighing from eight to ten or eleven pounds; ſometimes, too, it is ſcattered in much ſmaller fragments; and ſometimes even in ſtrata or layers. The inhabitants of Bleoux, a hamlet near Curban, in the higher part of Provence, work *native carbure of iron*, or plumbago, which is found in ſtrata of the thickneſs of four feet, between two beds of clay; the matter is ſold at Marſeilles. M. de la Peyroux reckons carbure of iron among the minerals of the Pyrenees: it is found in Spain and in Germany; in the duchy of Cumberland in England, there is a very rich mine of it; it is made into pencils, which are much eſteemed. North America, and the Cape of Good Hope, likewiſe afford ſpecimens of this ſubſtance. *Plumbago* has for ſome time been found in octohædral cryſtals.

Carbure of iron is of a gliſtering blackiſh blue colour; it feels greaſy, and its fracture is tuberculous; whereas, *molybdena* has a lamellated fracture. Its being of an unctuous ſoapy nature, has induced ſome chemiſts to conſider it as a kind of impure clay. It ſpots the hands; and the *black pencil* leaves, as every body knows, a blackiſh mark on paper.

Carbure of iron ſuffers no alteration from heat in cloſe veſſels. M. Pelletier, who has made a ſeries of experiments on this ſubſtance, ſince Scheele, without obtaining, however, any different reſult, expoſed 200 grains of it in a well-ſtopped crucible of porcelain, to the heat of the fire uſed in the Sêves manufactory for porcelain; the

the mineral loſt only ten grains: But when heated in contact with air, it burns and is oxidated, ſo as to leave ſcarce any reſidue. Meſſrs Quiſt, Gahn, and Hielm, obſerved, that 100 grains, treated in this manner, in a capſule under a muffle, left only ten grains of ferruginous oxide. This oxidation is a ſlow combuſtion, very difficult to bring about. It does not ſucceed in a common crucible: but to effect it, a thin piece of carbure of iron muſt be expoſed in a broad flat veſſel to the action of a ſtrong fire, and the ſurfaces often cleared, and its poſition changed.

Neither air, water, nor any earthy ſubſtance, acts on carbure of iron. The alkalis act powerfully on this ſubſtance. If one part of carbure of iron, with two of dry cauſtic fixed alkali, or the *lapis cauſticus*, be heated together in a retort with a pneumato-chemical apparatus, the ſmall quantity of water ſtill contained in the ſalt contributes to the combuſtion of this ſubſtance; a product of carbonated hydrogenous gas is obtained; the alkali is found to be ſaturated with carbonic acid; and there remains ſcarce any of the carbure of iron. The reſult of this experiment, and the detonation of carbure of iron with nitre, which will hereafter come under our notice, led Scheele to conſider this matter as a kind of ſulphur formed of *aerial*, or carbonic acid and phlogiſton. We will examine this theory, after having conſidered the other phænomena which this combuſtible body diſplays when expoſed to the action of acids and neutral ſalts.

The ſulphuric acid, according to Scheele, is incapable of acting on carbure of iron. M. Pelletier has obſerved, that when 100 grains of this ſubſtance, and four

ounces of concentrated ſulphuric acid, are digeſted together cold for ſeveral months, the acid acquires a green colour, and becomes liable to congeal by a very moderate degree of cold. This acid, when diſtilled on carbure of iron, paſſes into the ſtate of ſulphureous acid, in conſequence of the combuſtion of a part of that ſubſtance.

The nitric acid produces no alteration upon it. The muriatic acid diſſolves the aluminous earth and the iron, and ſerves to purify it, according to M. Berthollet. M. Pelletier has made uſe of the ſame proceſs in order to obtain pure carbure of iron. With reſpect to the aluminous earth, which the muriatic acid carries off from carbure of iron, Scheele remarks, that the aluminous earth ſeparated in his analyſis, belonged to the crucible in which he had before treated it.

Carbure of iron, when melted with four parts of ſulphate of potaſh, or ſulphate of ſoda, affords alkaline ſulphures, and is entirely decompoſed.

Nitre detonates with the help of this ſubſtance; ten parts of that ſalt are requiſite to burn one of carbure of iron. The fixed alkali which remains after this operation gives a lively efferveſcence with acids, and is found to be mixed with a ſmall quantity of oxide of iron. The ſame effect takes place with nitrate of ſoda and ammoniacal nitrate. M. Pelletier has obſerved, that in this laſt operation there is ammonaic diſengaged in combination with a portion of carbonic acid.

Carbure of iron acts neither on muriate of potaſh nor muriate of ſoda.

When diſtilled with ammoniacal muriate, it gives *martial ammoniacal flowers*. When it is heated with ſulphur

ſulphur in a retort, the ſulphur is ſublimed by itſelf, without producing any alteration on the carbure of iron.

All theſe facts concur to prove, that this ſubſtance is neither earth nor lead ore, as it was thought to be. But Scheele's Theory, again, who conſiders it as a combination of carbonic acid with phlogiſton, cannot be admitted, 1. Becauſe that chemiſt has not informed us what quantity of the acid he obtained; 2. Becauſe he could not compoſe *plumbago* artificially, by combining carbonic acid with a combuſtible matter. Beſides, the two ſubſtances with which Scheele changed carbure of iron into carbonic acid, effect the change by affording vital air, which combines with the inflammable matter of this ſubſtance, and gives riſe to that acid by the fixation of oxigene; for in this manner does the nitric acid convert tungſten, arſenic, and ſugar, into acids. With regard to cauſtic fixed alkali, which likewiſe changes carbure of iron into carbonic acid, this effect is plainly owing to the water which that alkali always contains, and which burns the combuſtible matter in the ſame manner as it conſumes zinc and iron; the hydrogenous gas obtained during the re-action of the alkali and the carbure of iron adds confirmation to this theory. It might be ſtill farther confirmed by paſſing water in vapours upon this ſubſtance, made red-hot in a copper or porcelain tube, as is done with iron and zinc. Although this experiment has not been yet made, I believe I may venture to advance, that the whole of the carbure of iron would be deſtroyed, and converted into carbonic acid, and that the product of the operation would be carbonated hydrogenous gas, mixed with a large

large proportion of carbonic acid. It would then ſeem a natural inference, that the carbonic acid is a compound of plumbago and oxigene; but as we know from many other experiments, that this acid cannot be found unleſs when a combination of carbone and oxigene takes place; we muſt infer, in this inſtance, that *plumbago* contains a large proportion of carbone, and even conſiſts almoſt entirely of that combuſtible body. A few facts concerning the properties of carbone, here thrown together, will farther confirm this aſſertion.

The carbone or coal of various vegetable matters is brilliant, and has a metallic aſpect, like carbure of iron; it ſoils the hands, and marks paper like that matter; and its texture too is granulated and brittle. The moſt brilliant coals, ſuch as thoſe of ſome animal ſubſtances, are as difficult to burn as carbure of iron, which needs to be much ſtirred, expoſed to an intenſe heat, and brought as much as poſſible into contact with air, in order that it may be conſumed; iron is found in both: And laſtly, theſe two ſubſtances are both liable to be changed into carbonic acid by combuſtion. After conſidering theſe facts, may we not regard *plumbago* as coal formed in the interior parts of the globe, or buried in the earth? May we not even conclude, that this matter is formed by the combination of ſome mineral principles? though almoſt all chemiſts be of opinion, that nothing but organic matters can be converted into coal. But this notion can be confirmed or refuted only by a regular inquiry into the ſtate of carbure of iron in nature, the circumſtances of its formation, and the alteration which it ſuffers. Since the reſearches of Meſſrs Vandermonde, Monge, and Berthollet, into the ſeveral ſtates in which iron ſubſiſts, diſcovered

diſcovered theſe facts concerning carbure of iron, they have farther diſcovered, that there is conſtantly formed, on the fuſion of caſt iron, a ſubſtance preciſely ſimilar to native carbure of iron. The ladles with which the caſt iron is taken out to cool are uſually coated with it. Maſſes of it are likewiſe found in cryſtals in repairing the upper parts of the furnaces. We may venture to hope that it will be one day artificially prepared for the ſervice of the arts.

Carbure of iron is a good deal uſed. It is made into pencils; the moſt eſteemed of which come from England. Keſwick, in the county of Cumberland, is the place where that uſed for pencils is found. The native lumps are ſawed into ſmall ſlender pieces; which are put into wooden cylinders with grooves, and cut ſo that the cavity of the cylinder may be entirely filled. The duſt produced from the ſawing and cutting of the pieces inſerted into the cylinders is uſed for pencils of an inferior quality, a great many of which are ſold at Paris. It is mixed with a gum paſte, or melted with ſulphur. Theſe baſe pencils are known in England, either by their melting and burning at the flame of a taper, or by their ſeparating into bits, and even falling into powder when ſteeped in water. The German carbure of iron is likewiſe uſed for pencils: in making them, ſeveral extraneous matters are added; ſuch as coal, ſulphur, &c. In England the fineſt duſt of carbure of iron is uſed for coating the wheel-work of ſome inſtruments; and it facilitates their motions by its greaſy unctuous nature *.

One of the moſt important uſes to which this ſubſtance

* This ſubſtance is likewiſe uſed for blackening the outſides of *coffins*. Its common name is *woad*. H.

ſtance is applied is to coat iron, in order to preſerve it from ruſting; the pipes of ſtoves, the back parts of grates, and other utenſils expoſed to the action of fire and air, are coated with powder of carbure of iron, which is applied to their ſurface by ſimply rubbing with a bruſh. Homberg, in the year 1699, deſcribed a proceſs for giving a leaden colour to utenſils of iron. It conſiſts in mixing eight pounds of melted animal fat, with four ounces of camphire, and a ſufficient quantity of carbure of iron, and laying this compoſition on iron ſo hot that it can ſcarce be held in the hand: theſe utenſils muſt be carefully wiped with a cloth, after being covered with this ſort of varniſh.

The workmen who manufacture lead for hunting-ſhot, poliſh and blacken its ſurface at the ſame time by rolling it in powder of carbure of iron. It is likewiſe a part of the compoſition put upon the pieces of leather uſed for ſtrapping razors. Laſtly, it is uſed in the manufacture of ſeveral black Engliſh earthen wares; and in that of the crucibles which are made at Paſſaw in Saxony.

M. Pelletier, who has given a good account of the various uſes to which carbure of iron is applied, found it to anſwer very well in a luting which he prepared after Pott, with one part of this ſubſtance, three of common clay, and a little cow-dung, reduced very ſmall. This luting ſupports glaſs retorts well enough: they even melt ſometimes without its ſuffering any change of form.

The principal uſes of iron are ſo extenſive, and beſides ſo well known, that it is unneceſſary to inſiſt on them here; only we may mention, that no art can do entirely without it, and that it is, as Macquer ſays, the ſoul of all the arts. The various modifications of which

it

it is ſuſceptible, render it very ſuitable for all the purpoſes to which it is applied. Caſt iron is run into utenſils more or leſs ſolid, and capable of reſiſtance, according to the purpoſes for which they are deſigned. The tenacity and hardneſs of the ſeveral ſpecies of forged iron render it very ſuitable for all the purpoſes to which it is applied. The ſame is the caſe with the ſeveral kinds of ſteel. The fineneſs of the grain and the temper vary ſo as to divide it into a great many ſpecies, each of which is better fitted than any of the reſt to ſome purpoſe or other in the circle of the arts Oxides of iron ſerve for giving a red or brown colour to procelain, pottery, enamels, &c. They are likewiſe employed in the preparation of artificial precious ſtones, and mixed with oil for painting colours.

Iron affords a remedy of great uſe in medicine; to which indeed the art is frequently indebted for ſucceſs. This is the only metal that has no noxious quality whatever, and of the good effects of which there can be no doubt. There is even, as we have ſeen, ſuch an analogy between iron and organic matters, that it ſeems to compoſe a part of them, and to be often produced by the operation of the vital powers of animals, and by vegetation. The effects of iron on the animal œconomy are various. It ſtimulates the fibres of the membraneous viſcera, and appears to act more eſpecially on thoſe of the muſcles, which it affects as a tonic. It fortifies the nerves, and communicates to the animal, when enfeebled and languid, new force and vigour in a remarkable degree. It excites many ſecretions, eſpecially ſuch as take place by evacuations of blood or urine. It contributes to bring on natural hæmorrhages, ſuch as the menſtrual flux and the hæmorrhoids.

It increaſes and multiplies the contractions of the heart; and of conſequence renders the pulſe quicker and ſtronger. It acts with no leſs energy on the fluids. It paſſes eaſily into the channels through which the blood circulates, combines with it, and thus gives it new denſity, conſiſtency, and colour, and renders it more liable to concretion. It at the ſame time communicates to it ſuch activity, that it paſſes without difficulty into the ſmalleſt veſſels, ſtimulates of itſelf the ſides of the ducts through which it flows, and thus conveys life and vigour through the whole ſyſtem. The valuable experiments of M. Menghini, publiſhed among the Memoirs of the Inſtitution of Berlin, prove, that the blood of people who make uſe of iron is higher coloured, and contains more than the natural quantity of this metal. Lorry, who, in the practice of medicine, has diſplayed that nice acuteneſs of obſervation, and that extenſion of views which diſtinguiſh the profound and philoſophical phyſician, obſerved the urine of a ſick perſon to whom he had adminiſtered iron reduced to powder, to take a manifeſt colour from an infuſion of nut-gall. This metal is therefore tonic, ſtrengthening, ſtomachic, diuretic, alterative, inciſive; and in the ſingle operation of this medicine are united the virtues of a great number of drugs. It contracts the fibres like aſtringents, it increaſes their oſcillation: and it has the ſuperiority over many of the other medicines which poſſeſs the ſame virtues, as being more conſtant and durable in its effects; for it combines with the organs themſelves, by means of the fluids by which theſe are nouriſhed. It may be uſefully adminiſtered, therefore, in all caſes in which the action of the

fibres of the viſcera, of the muſcles, or even of the nerves, is very feeble; when the ſtomach and inteſtines are ſo languid as to refuſe their functions; and in the caſe of weakneſs ariſing from ſuch a cauſe: in ſhort, whenever the conſiſtency of the fluids is diminiſhed, and they are become too thin, as in the green ſickneſs, and in tendency to dropſy, &c. It is uſed under many different forms; ſuch as levigated filings, martial Æthiops, aſtringent and aperitive ſaffron of Mars, Stahl's alkaline martial tincture, martial flowers of ſal ammoniac, &c. To theſe medicines might perhaps be added iron precipitated from acids, and again diſſolved by ammoniac; Pruſſian blue, the uſe of which as a medicine, is propoſed by the chemiſts of the Academy of Dijon, &c. Sulphate of iron is applied externally to ſtop hæmorrhages, &c.

Iron, endowed with magnetic qualities, or artificial loadſtone, has been thought to produce ſome very ſingular effects on the animal œconomy. According to many modern authors, when laid upon the ſkin, it eaſes pain, ſtops convulſions, occaſions redneſs, ſweating, and often, too, the eruption of ſmall pimples; it likewiſe renders epileptic fits leſs frequent. We are even aſſured, that in the ſpace of twelve hours it communicates to water a purgative quality. Theſe aſſertions, which it is pretended are juſtified by facts, afford ſo many proofs to enlightened philoſophers of the difficulties with which the ſtudy of animal phyſics is attended. As no body is liable to be affected by the magnetic powers of other bodies which is not itſelf capable of acquiring ſuch powers, it muſt therefore be impoſſible for the loadſtone to act by virtue of its magnetic powers upon the animal

œconomy.

œconomy. The phyſicians who aſcribe to it ſuch eminent effects, and ſuch energetic medicinal powers, have been miſled and deceived by the changes, more or leſs ſenſible, which have taken place about the time of the application of the magnetic body, and have been owing to the circumſtances of the caſe, and the happy exertions of nature. This opinion is farther enforced by conſidering, that nature ſeems to act with more irregularity and inconſtancy in removing pains and convulſions, than in any other inſtance; and that the medicinal virtues of the loadſtone are chiefly inferred from the effects which have followed after applying it in caſes of this kind.

To this very elaborate and complete chapter upon *iron*, very few facts can be added.

M. Chaptal ſays, that the cubic foot of iron, weighs not 880 *lib.* as our author alledges, but only 845 *lib.* Its ſpecific gravity is 72,070. Iron ochres, ſuppoſed to be formed by the natural decompoſition of pyrites, are the principal matter employed for dyeing *ſtuffs* with the various ſhades of *brown-red*. They are for this purpoſe calcined. At Maz-Dieu, near Alais in France, a ſtratum of ochre has been found, which affords an inimitable *red*. At Carron in Stirlingſhire, in Scotland, and by Meſſrs Cooper and Barker, between Leith and Edinburgh, many articles of furniture, &c. are very ingeniouſly moulded out of crude iron. H. —

CHAP. XIX.

Of Copper.

COPPER is a metal, of a very brilliant red colour, to which the alchemiſts gave the name of *Venus*, on account of the readineſs with which it combines ſo as to ſuffer alteration from a vaſt variety of other bodies. It has a diſagreeable ſmell, which is felt when it is rubbed or heated. Its taſte is ſtiptic and nauſeous, but leſs ſenſible than that of iron. It is hard, very elaſtic, and very ſonorous. Its ductility is conſiderable: it is reducible into very thin plates, and very ſlender threads. In the hydroſtatic balance, it loſes about an eighth or a ninth part of its weight. Such is its tenacity, that a thread of copper, one-tenth of an inch in diameter, ſupports 299 1-4th pounds weight without breaking. Its fracture appears as if it were compoſed of ſmall grains. It is ſuſceptible of a regular form. The Abbé Mongez defines its cryſtals to be quadrangular pyramids, ſometimes ſolid, and ſometimes conſiſting of other ſmaller pyramids, inſerted laterally.

Copper

Copper is found in various ſtates in the earth. Its ores are very numerous; but they may be all reduced to the following.

1. Native copper of a red colour, malleable, and poſſeſſed of all the other properties of the metal. It is diſtinguiſhed into two ſorts; copper of the firſt formation, and copper of a ſecondary formation, or cementation. The copper of the firſt formation is diſperſed in plates or filaments within a gangue, which is almoſt always of a quartzoſe nature. It is ſometimes found in octahædral cryſtals, one above another, reſembling a kind of vegetation. There are other ſpecimens in maſſes and grains. Copper of cementation is commonly in grains, or in thin laminæ on the ſurfaces of ſtones or iron. That which is found on iron appears to have been depoſited in waters containing ſulphate of copper, and precipitated by iron. Native copper is found in many places over Europe: At St Bel in the neighbourhood of Lyons, at Norberg in Sweden, at Newſol in Hungary, and in ſeveral parts of America *.

2. Copper oxidated and mineralized by the carbonic acid. There are ſeveral varieties of native carbonate of copper.

Varieties.

A. Red copper, or *hepatic copper ore*. This ore is diſtinguiſhed by its dark red colour, like the colour of the ſcales which fall off from copper made red-hot, and then ſtruck with a hammer. M. Monnet conſiders this ore as a natural

* Alſo in different places in England, Scotland, and Wales, at Haumſdorf in Thuringia, &c.

Varieties.

tural oxide of copper. It is generally mixed with native copper and *mountain green:* it is not very plenteous; ſometimes it is found in octahædral cryſtrals, or ſilky fibres called *flowers of copper.*

B. *Earthy copper, mountain green,* or *green chryſocolla.* This ore is a genuine oxide of copper, of a lighter or a deeper green, not heavy, and unequally diſperſed within its gangue. It appears from the analyſis of the malachite, made by the Abbé Fontana, to be combined with carbonic acid. This ore is ſometimes very pure. It may be conſidered as exiſting in three different ſtates.

Simple *mountain green,* earthy or impure, called alſo *green chryſocolla.*

Mountain green in cryſtals, or *ſilky copper* of China. This ore, which is common enough in Voſges and Hartz, is likewiſe found in China. It is pure, and cryſtallized in long ſilky bundles of no ſmall ſolidity.

Mountain green in ſtalactites, or *malachite.* This ſubſtance, which is found in conſiderable abundance in Siberia, conſiſts of layers in the form of nipples, of various ſizes: ſome of the ſpecimens conſiſt of needles converging towards a common centre. The different layers have not all preciſely the ſame ſhade of green. The malachite is hard enough to take a fine poliſh; and various toys are made out of it; but as it is often porous, and full of unequal cavities, the

Varieties.

the ſolid pieces are always the moſt valuable when they come up to a certain ſize.

C. *Mountain blue*, or *blue chryſocolla.* This is an oxide of copper of a deep blue colour; it is ſometimes in a regular form, and in rhomboidal priſmatic cryſtals of a very beautiful blue. It is then called *copper azure.* At other times, it is found in ſmall grains, depoſited in the cavities of different gangues, more eſpecially in quartz. Generally, however, it is in thin layers, in the cavities of grey and yellow copper ores. It appears, that all theſe oxides of copper have been precipitated from ſulphuric ſolutions of this metal by the intermedium of calcareous earths, through which the waters containing them flow. M. Sage conſiders theſe blue copper ores as combinations of copper with ammoniac; and ſays, that they differ from it only in being inſoluble. He likewiſe thinks, that the malachite is nothing but this blue, which he calls tranſparent azure copper ore, with a ſmall alteration. But this opinion is not generally received among the mineralogiſts. M. de Morveau thinks, that the blue differs from the green oxide of copper only in containing a ſmaller proportion of oxigene.

The blue oxide of copper ſeems to be the matter which colours certain ſtones; the turquois ſtone particularly, in which Reamur found copper, appears to owe its colour to this cauſe, as well as the Armenian ſtone, the

Varieties.

baſe of which is calcareous carbonate, or ſulphate of lime. Mr Kirwan makes a ſpecies of copper ore of theſe blue ſtones. The turquois is formed of animal bones, coloured by copper. According to Reamur, the Perſian turquois is not liable to ſuffer from the attacks of the nitric acid. The ſame acid entirely diſſolves the turquois of Languedoc.

3. Copper mineralized by the muriatic acid and combined with clay. M. Werner ſpeaks of this ore in his tranſlation of Cronſtedt. It has been confounded with talc; and a perſon of the name of *Dans* expoſed it to ſale at Paris in the year 1784, under the name of *green mica*. It is in ſmall cryſtals of a beautiful green colour, or in ſmall ſparkling ſcales. Mr Forſter found ſpecimens of this in the mines of Johan Georgenſtadt. The green copper ſand brought from Peru by M. Dombey ſeems to belong to this ſpecies of copper ore: on analyſing it, I have found it to contain a little muriatic acid.

4. Copper mineralized by ſulphur almoſt without iron. It is called *vitreous copper ore*; but the name is very improper. It is dark-grey, violet, brown, greeniſh, or entirely brown and liver-colour. A very moderate heat melts it. It is ponderous, ſometimes flexible, and always of ſuch a conſiſtency, that it may be cut with a knife. In its fracture it appears brilliant like gold. It is one of the richeſt copper ores; for it affords no leſs than 90 pounds of copper in the hundred weight.

5. Copper

5. Copper mineralized by ſulphur with more iron than is contained in the ſpecies immediately preceding; azure copper ore. It differs from the laſt only in containing about 30 pounds to the hundred weight; it affords only from 50 to 60 pounds of copper in the hundred weight; the reſt is ſulphur. Theſe two ores may be aſſayed by acids.

6. Copper mineralized by ſulphur with a good deal of iron; brilliant or yellow golden pyrites. The quantity of the ſulphur and the copper varies greatly in this ore; the iron is always in a very conſiderable proportion. It exiſts in the earth in veins more or leſs conſiderable. This ore is ſometimes maſſy and dark, often ſcaly, and ſeemingly micaceous. Such is the form of that of Denmark, Norway, Sweden, and St Marie-aux-Mines. On other occaſions, this ore is diſperſed in its gangue, as the copper of Alſace; it is then called *ſpeckled copper ore.* This variety is often mixed with a little azure; coppery pyrites exhibit very brilliant colours on their ſurface, either blue or violet, which are owing to the decompoſition of their principles. They are then called *copper with a waving light*, or *peacock-tail copper ores.* They uſually contain a great quantity of ſulphur, a little iron; and in copper they are not very rich. When theſe ores are only ſuperficially diſperſed on the gangue, they are more particularly diſtinguiſhed by the name of *copper pyrites*: Of which kind are the ores of Derbyſhire in England, ſome of thoſe of St Bel in the Lyonnois, and a number in the mines of Alſace, as at Caulenbach and Feldens. They are beſides found adhering to gangues of all ſorts, rock-cryſtal, quartz, ſpar, ſchiſtus, and mica, &c.

7. Copper united with ſulphur, iron, and a little ſilver. This ore is called *arſenical copper ore*, or *fahlertz*, and bears a great reſemblance to the grey ſilver ore; only it is not juſt ſo brilliant; the only difference is, that this copper ore contains leſs ſilver than the other. M. Romé de Lille takes notice likewiſe of a white copper ore, which, according to him, contains a little more ſilver than the grey: but that is a true ſilver ore. Fahlertz affords from 35 to 60 pounds of copper in the hundred weight.

8. Copper mineralized by ſulphur and arſenic, with zinc and iron; *brown*, or *blendy copper ore*. M. Monnet found this ore no where but at Catharineberg in Bohemia: it is brown, granulated, and very hard. It contains from 18 to 30 pounds of copper in the hundred weight.

9. Schiſtous copper ore. This is *vitreous copper*, very intimately mixed with brown or black ſchiſtus. It affords from 6 to 10 pounds in the hundred weight: chalk muſt be added when it is melted.

10. Bituminous copper ore. This is copper mixed in a particular ſort of Swediſh turfs.

11. Black, or pitch-coloured copper ore. M. Gellert calls it *copper ore in ſcoriæ*: it is a reſidue remaining after the decompoſition of yellow and grey copper ores, which contains neither ſulphur nor arſenic, and is nearly in the ſtate of *malachite*. It is of a gliſtering black colour like pitch.

12. Copper combined with ſulphur and arſenic, containing antimony; antimonial copper ore. M. Sage mentions this ore in his Elements of Mineralogy. It is grey and brilliant in its fracture, like antimony. It contains

" tains from 14 to 20 pounds of copper in the hundred weight.

To aſſay a copper ore, after being pounded and waſhed, it muſt be ſubjected to long roaſting by an intenſe " heat, and melted with four times its own weight of black flux and marine ſalt. The button thus obtained, which is often blackened with a reſidue of the ſulphur, is next to be melted with four parts of lead, and paſſed into a cupel, where the ſilver and gold which it contains may be ſeparated; for there is but very little copper which does not contain ſome portions of theſe precious metals. M. Tillet's flux, which is a mixture of two parts of pounded glaſs, with one of calcined borax, and an eighth of coal, ſucceeds better in reducing this metal than black flux; for the black flux forms an alkaline ſulphure, which diſſolves a part of the oxide of copper.

Bergman recommends the ſulphuric and the nitric acids for aſſaying copper ores in the humid way. When the copper has been diſſolved by the acids, it is then precipitated by iron

In working copper ores in the great way, they are firſt pounded and waſhed; they are then roaſted at the firſt in the open air, and almoſt without wood; for when the ſulphur which they contain, is once kindled, it burns away of itſelf. When it ceaſes to burn, the ore is then roaſted anew, and even twice ſucceſſively on wood, in order to obtain what is called *the mat of copper.* This is the ore after it has loſt only a portion of the ſulphur which it contained. The fuſion to which it is ſubjected ſerves to make it expoſe its ſurfaces more entirely to the heat; in conſequence of which it

is more thoroughly roaſted. It is expoſed to ſix or ſeven ſucceſſive roaſtings, according as it contains more or leſs ſulphur, and is then melted into *black copper*. This copper is malleable: ſtill, however, there is ſo much ſulphur united with it, which cannot be ſeparated without extracting at the ſame time the perfect metals which it contains. The black copper is melted with three times its quantity of lead, which is called *refreſhing the copper;* and this mixture is moulded into the form of loaves, which are called loaves of *eliquation*. Theſe are inſtantly placed on two plates of iron, inclined ſo as to leave a gutter between them. They terminate immediately over the furnace of eliquation; the under part of which ſlopes forward. The fire under the plates heats the loaves: the lead melts, and runs under the coals, carrying with it the ſilver and the gold, with which it has a greater affinity than with copper. After this operation, the cakes are found to be conſiderably diminiſhed, and to have loſt their ſhape. They are now expoſed to a ſtronger fire; the heat of which is ſo intenſe as to melt the copper, ſo far that it may be entirely ſeparated from the lead. This third operation is called (in French) *reſſuage*. The lead, with the perfect metals, is taken to the cupel. As to the copper, it is refined by melting it in a crucible, and ſuffering it to ſtand ſo long melted, that it may throw up, in a ſcum, any extraneous matters which it contains. It is aſſayed by dipping into it iron rods, which take up a little copper; and from its being more or leſs of a bright red colour, a judgment is formed of the purity of the metal. Copper thus refined is run into plates, or divided into *roſettes*. To form a *roſette*, the

ſcoriæ

" ſcoriæ with which copper in fuſion is covered are care-
" fully taken off. The ſurface of the metal is ſuffered to ſettle and fix: when it ceaſes to be fluid, it is ſweeped over with a wet beſom: The impreſſion of cold contracts it. The portion congealed ſeparates not only from the edges of the crucible, but likewiſe from the reſt of the melted metal, and is taken off with pincers. Moſt part of the copper in the crucible is thus taken off in *roſettes*. What remains at the bottom is called *the king*.

Cupreous pyrites, containing but little of the metal, are wrought ſolely for the ſulphur and the vitriol. At St Bell, and in many other places, they are roaſted and diſtilled, in order to ſeparate the ſulphur. During the roaſting, a portion of the ſulphuric acid acts on the metal, diſſolves it, and thus begins to form a ſulphate of copper. The roaſted pyrites are next expoſed to the air; and when the *vitriolization* is ended, the pyritous efflorescence is lixiviated, the lixivium filtrated and evaporated, in order that it may afford a blue rhomboidal ſalt in cryſtals, called *vitriol of copper*, *blue vitriol*, *blue copperas*, or *vitriol of Cyprus*. We ſhall ſpeak of it when we come to examine the combinations of this metal, under the name of ſulphate of copper.

Copper, when expoſed to fire, takes nearly the ſame colours with ſteel: it becomes firſt blue, then yellow, and at laſt violet. It does not melt unleſs when very red. When fully in fuſion, it appears covered over with a green flame: it boils, and is capable of volatilization, as may be obſerved in the chimnies of founders. There are alſo found flowers of copper in the crucibles in which it is ſmelted. Small filings of this metal,

when

when thrown into the flames, give them a blue and green colour. It is uſed in artificial fire-works, on account of this property. If this melted metal be ſlowly cooled, and the fluid portion decanted off, that which adheres to the ſides of the crucible, or roaſting pot, employed in the experiment, is found in pyramidal cryſtals; which are larger and more regular in proportion as the fuſion of the metal has been more complete, and its cooling more ſlowly brought on. The pyramids are quadrangular, and appear to conſiſt of a number of octahædrons diſpoſed one over another.

Copper heated in contact with air, burns at the ſurface, and changes into a blackiſh red oxide, as it abſorbs the baſe of vital air. This oxide may be eaſily obtained by making a copper-plate red-hot, and then ſtriking it with a hammer; the oxide comes off in ſcales. The ſame thing takes place when a copper-plate is dipped in cold water, after being made red-hot. The ſudden contraction of the parts of the metal contributes to the ſeparation of the oxide which covers its ſurface. The oxide falls to the bottom of the water; it is called *ſcales of copper*. As the copper is not completely oxidated, it may be burnt anew under the muffle of a cupelling furnace; it then takes a pretty deep brown colour; when urged with a violent heat, it melts into a blackiſh or brown cheſnut-coloured glaſs. Oxide of copper may be decompoſed, and deprived of its oxigene, which deſtroys its metallic properties, by oils, reſins, &c. The ſcales are in part reducible by themſelves; for founders buy them from copperſmiths, and uſe no means for their reduction but throwing them into large crucibles, above melted copper, with which, as they melt,

melt, they enter into union. The filings of this metal are melted in the ſame way. Oxide of copper appears to poſſeſs ſome ſaline properties; but its nature, as a ſalt, has not yet been the ſubject of examination.

Air acts upon copper; and the more eaſily, the more it is loaded with, and altered by moiſture. It converts it into a ruſt, or green oxide, which appears to have ſome ſaline properties: it has a taſte, and is liable to be acted upon by water: Such was the reaſon which induced the ancient chemiſts to conſider copper as containing a ſalt. One thing remarkable with regard to this ſalt is, that it never penetrates deeper than the ſurface, and ſeems to contribute to the preſervation of the interior parts of a maſs of this metal; as may be inferred from the ſtate of ancient medals and ſtatues, which are well preſerved under the coat of ruſt with which they are covered. Antiquaries call that ruſt *patina*, and ſet an high value on it; becauſe it is a proof of the antiquity of thoſe pieces which are covered with it. There are many artiſts, eſpecially Italians, who know how to imitate this ruſt on copper; and thus counterfeit ancient pieces of bronze.

The oxidation of copper by humid air, appears to be owing to water in a ſtate of extreme diviſion. This fluid, however, does not appear to attack copper in the ſame manner as iron at an high temperature. It ſhould rather ſeem, that cold water oxidates the metal; for it is known to be more dangerous to leave liquors to cool, than to boil them in copper veſſels. When the liquor is boiling, and the veſſel hot, the aqueous vapour does not attack the ſurface of the metal; but when the liquor

quor is cold, the drops which adhere to the ſides of the veſſel appear to reduce the copper to a green oxide. This oxidation may be therefore aſcribed, with great probability, to the operation of the air, and the carbonic acid diffuſed through it; for, on diſtilling this ruſt of copper in a pneumato-chemical apparatus, I obtained from it carbonic acid.

Copper does not combine with earthy matters. Its oxide, however, contributes to their fuſion, and combines with them to form brown glaſſes of a lighter or a deeper ſhade.

Barytes, magneſia, and lime, act not in a diſcernible manner on copper: we know not how they act on the oxide of this metal.

Cauſtic fixed alkali, digeſted cold with filings of copper, aſſumes in a certain time, a very light blue ſhade; and the copper is covered over with a duſt of the ſame colour. According to M. Monnet, theſe ſolutions are better effected in cold than in heat. It is, however, of importance to obſerve, that he made the combination with carbonate of potaſh, not with pure fixed alkali. Pure fixed alkali ſeems to have much more influence on copper: But neither of theſe ſalts does any thing more than promote and haſten the precipitation of the oxigene of the atmoſphere into copper; for the oxidation never takes place without the concourſe of air.

This phænomenon is more eſpecially remarkable, when ammoniac is brought into contact with copper; on which occaſion the metal is very ſoon diſſolved. When ammoniac is digeſted on filings of copper, with concourſe of air, it takes, in a few hours, a very beautiful deep blue colour; there is not, however, much of the

the copper diſſolved. I have for a year obſerved the phænomena of this ſolution. I put into a ſmall phial a portion of the cauſtic ammoniac with copper ſilings; the phial was often unſtopped. At the end of ſome months, I found the ſurface of the metal covered with a blue oxide: its ſides were coated with a pale blue oxide; and the under part of the phial, containing the copper, diſplayed, at the ſurface of the glaſs, a brown oxide, the upper part of which was yelloviſh. When the phial containing this liquor is cloſely ſtopped, the liquor loſes its colour almoſt entirely; but whenever the phial is unſtopped, it appears again. It does not exhibit this phænomenon in an eminent degree, except in the beginning of the operation, and when it is decanted off the copper. If the ſolution be not newly made, and ſtill contain copper, it is of a beautiful blue colour, even in cloſe veſſels; however, when expoſed to the air, its colour becomes ſtill deeper. Theſe phænomena ſhow the influence of the oxigene of the atmoſphere.

When the ſolution of copper by ammoniac is ſlowly evaporated, moſt part of the ſalt is diſſipated; a portion, however, remains fixed with the oxide of the metal, and is depoſited in ſoft cryſtals; as has been obſerved by M. Monnet. M. Sage aſſerts, that very beautiful cryſtals may be obtained from this ſolution by ſlow evaporation; and compares them to natural azure of copper. This laſt ſubſtance, however, affords no ammoniac when heated; is not ſoluble in water; and does not effloreſce in the air, like that which is artificially prepared. M. Baumé ſays, this compound forms very brilliant cryſtals of a very beautiful blue colour. This ſo-

lution, when expoſed to the air, becomes very ſoon dry; and what remains is a matter of a graſs-green colour, which can be nothing but a green oxide of copper. M. Sage thinks this the origin of the malachite: but this oxide does not afford near ſo much carbonic acid as the malachite. An acid poured into the ſolution of copper by liquid ammoniac, produces ſcarce any precipitate, but changes the blue colour of the ſolution into a very light pale green. This phænomenon, which has been obſerved by Meſſrs Pott and Monnet, ſhows, that there is but very little oxide of copper in the ammoniac, and that it is again diſſolved by the acid, or by the ammoniacal ſalt, formed by the addition of the acid. By adding ammoniac to the mixture, however, it may be made to reſume its blue colour. Both the oxide of copper reduced to this ſtate by fire, and all the other oxides of this metal, are inſtantaneouſly diſſolved in pure ammoniac; and the ſalt may be thus impregnated with a conſiderable portion of the metal. It takes immediately a very beautiful blue colour; and on this account it has been propoſed to uſe it as a teſt for aſcertaining the preſence or abſence of copper in ſubſtances in which it may be ſuſpected to exiſt.

Ammoniacal oxide of copper, or oxide of copper united with ammoniac, is decompoſed into its two conſtituents, when expoſed to an intenſe heat. The oxigene leaves the copper to unite with the hydrogene of the ammoniac, and to form water; the copper returns to its metallic ſtate, and the azote, the other principle of ammoniac, is diſengaged in the form of gas. This experiment is one, among others, which led M. Berthollet to diſcover the nature of ammoniac. It appears

alſo, that a little nitre is likewiſe formed at the ſame time by the union of the azote of the ammoniac with a portion of the oxigene of the copper.

Though iron decompoſes the ſolutions of copper, in fact, however, by a different attraction, namely, that of the iron for the oxigene, the ſulphuric acid does not act on copper, except when concentrated and boiling: a good deal of ſulphureous gas is diſengaged while this ſolution takes place. When the ſolution is completed, the two ſubſtances are found to have formed a matter of the conſiſtency of jelly, containing oxide of copper by itſelf, and a portion of that oxide in combination with ſulphuric acid. By lixiviating this matter, and filtrating the lixivium, a blue ſolution is obtained; when evaporated to a certain point, and ſuffered to cool, this ſolution affords oblong rhomboidal cryſtals of a beautiful blue colour, which are ſulphate of copper. If, inſtead of being evaporated, this ſolution be left for a long time expoſed to the air, it affords cryſtals; but it likewiſe precipitates a green oxide,—the colour which all oxides of copper take that are either formed or dried in the air.

Sulphate of copper has a very ſtrong ſtiptic taſte; it is even cauſtic. When expoſed to fire, it melts very quickly: it loſes its water of cryſtallization, and takes a bluiſh white colour. A very ſtrong heat is requiſite to ſeparate the ſulphuric acid, which adheres much more obſtinately to oxide of copper than to oxide of iron. Sulphate of copper is decompoſed by magneſia and lime: the precipitate formed by either of theſe ſubſtances is of a bluiſh white colour: when dried in the air, it becomes green; on this account, chemiſts deſcribe the precipi-

tates of ſulphate of copper as green. The caſe is abſolutely the ſame with thoſe which are obtained by fixed alkalis in different ſtates; they are at firſt bluiſh, and take a green colour when dried: perhaps *mountain green* may be formed in this manner. It is of conſequence to obſerve, that when ſulphate of copper is precipitated by a ſolution of carbonate of potaſh, there is no effervescence excited; a circumſtance which proves that the carbonic acid unites very readily with oxide of copper. This phænomenon is not common to all ſolutions of metals. Ammoniac in the ſame manner cauſes ſulphate of copper to yield a bluiſh white ſolution; but the mixture ſoon takes a very deep blue colour; for the ammoniac diſſolves in ſome meaſure the precipitated copper; and a very little of that ſalt is ſufficient to diſſolve again the whole of the copper ſeparated from the ſulphuric acid.

The nitric acid diſſolves copper cold, and with rapidity. A good deal of very high-coloured nitrous gas is diſengaged from this ſolution. This method Dr Prieſtley employed in order to obtain this gas very ſtrong. A portion of the metal, reduced to oxide, is precipitated in a brown powder, and ſeparated from the ſolution by filtration. This ſolution, after being filtrated, appears of a much deeper blue colour than the ſolution of copper by the ſulphuric acid; which ſhows that the copper is here more completely oxidated. This ſolution, carefully evaporated, cryſtallizes by cooling. Macquer, in his Memoir on the ſolubility of ſalts in alcohol, was one of the firſt chemiſts who obſerved this fact. If the cryſtals be very ſlowly formed, they become oblong parallelograms; if depoſited more quickly, hexahædral

hædral priſms, the points of which are obtruſe and irregularly formed, and which appear like bundles of divergent needles. Laſtly, when this ſolution is too quickly evaporated, it affords only a magma of no regular form. This, no doubt, is what has made chemiſts ſay, that the ſolution is not ſuſceptible of cryſtallization. Nitrate of copper is of a very bright blue colour. It is ſo cauſtic, that it may be applied to corrode excreſcences growing on the ſkin. It melts, according to M. Sage, at a temperature of 77° degrees of Fahrenheit's thermometer. It detonizes on burning coals; but as it contains a good deal of water, the phænomenon is not very diſcernible. When melted in a crucible, it exhales a good deal of nitrous vapour, which may be collected by diſtilling it; when dried, its colour is green; when ſtill farther urged with heat, it becomes brown; it is now nothing but pure oxide of copper. I have diſtilled a quantity of it in a pneumato-chemical apparatus, and it afforded a good deal of nitrous gas, a little carbonic acid, and a little vital air: by this operation it was reduced into the ſtate of brown oxide. Nitrate of copper attracts the moiſture of the atmoſphere. It may, however, be preſerved for a long time in cloſe veſſels. When expoſed to a hot dry air, it is covered over with a green efflorescence. It is very ſoluble in water, and rather more ſoluble in hot than in cold water. The ſolution, if expoſed to the air in flat veſſels, or haſtily evaporated in dry warm weather, leaves a green oxide, ſuch as the cryſtals of the ſalt leave on a ſimilar occaſion. Lime makes it yield a pale blue precipitate; fixed alkali, a bluiſh white precipitate; by ammoniac it yields flakes of the ſame colour, which are very quickly diſſolved,

 33515 and

and communicate to the liquor a very bright deep blue tincture. Its precipitate by alkaline ſulphures is of a browniſh red colour, without a fœtid ſmell; with the tincture of nut-gall, it gives an olive green precipitate. The ſulphuric acid likewiſe decompoſes nitrate of copper; and if it be employed in an highly concentrated ſtate, cryſtals of ſulphate of copper are obtained. Stahl firſt took notice of this decompoſition; M. Monnet has ſince confirmed the fact related by Stahl; and I have ſeveral times had occaſion to obſerve it. Iron has been ſaid to have a greater affinity than copper with moſt of the acids. When a plate of this metal is immerſed into a ſolution of copper in the acids, particularly in the nitric acid, the copper is precipitated in a metallic form, and colours the ſurface of the iron: but the iron effects this precipitation in conſequence of its having a ſtronger affinity with oxigene than copper has. The copper again, after loſing this principle, can no longer remain united with the acid, whilſt the iron, after being oxidated, readily continues with it. Sulphate of copper diſplays the ſame phænomenon; and jugglers, by this proceſs, make ignorant people believe that they can change iron into copper.

The muriatic acid diſſolves copper only when concentrated and boiling; only a very little hydrogenous gas is diſengaged when this ſolution takes place. The muriatic acid takes a very deep green, almoſt a brown colour. This combination forms a magma, which diſſolves readily enough in water; if this magma be lixiviated, the water is of a beautiful green colour; a circumſtance which ſerves to diſtinguiſh this from the two preceding ſolutions. On evaporating it ſlowly, and ſuffering

fering it to cool, it depoſites priſmatic cryſtals ſufficiently regular, if the evaporation have been cautiouſly managed; but if the evaporation has been too quick, and the cooling too ſudden, they then appear under the form of very ſmall ſharp needles. Muriate of copper is of a graſs-green colour, very pleaſing to behold: its taſte is cauſtic, and very aſtringent; it melts by a very moderate heat, and when ſuffered to cool, congeals into a maſs. M. Monnet affirms, that the muriatic acid adheres to it with great obſtinacy, and that a very conſiderable heat muſt be applied to volatilize it: it powerfully attracts the moiſture of the atmoſphere; it is decompoſable by the ſame intermedia which decompoſe the preceding ſalts of copper. I have obſerved, that ammoniac does not diſſolve the oxide which it ſeparates from the muriatic acid, ſo readily as that which it ſeparates from the ſulphuric and the nitric acids. The blue then formed is not ſo lively, and there remains a portion of the oxide, which the ammoniac does not thoroughly diſſolve. Neither the ſulphuric nor the nitric acid decompoſes muriate of copper. The nitric ſolutions of mercury and ſilver decompoſe it, and are themſelves decompoſed at the inſtant of the mixture. A white precipitate is formed in conſequence of the muriatic acid uniting with the oxide of mercury or ſilver; and the oxide of copper combines with the nitric acid. I have however obſerved, that this liquor does not aſſume the blue colour which a ſolution of copper by the acid of nitre ought to have; and that, in general, the oxide of copper formed by the muriatic acid, does not aſſume this colour but with great difficulty, as we have already ſeen with regard to ammoniac. I have

found, that in general oxides of copper paſs very eaſily from blue to green, and with very great difficulty from green to blue. The muriatic acid diſſolves oxide of copper much eaſier than copper itſelf. This has been obſerved by Brandt. The colour of the ſolution is a beautiful green; and it cryſtallizes as the former: a circumſtance which proves, that in ſaline metallic combinations, the metals are always in the ſtate of oxides, as we have already obſerved.

Nitre detonizes with difficulty by copper. The ſalt muſt be in fuſion, and the copper very hot, in order that the deflagration may take place: ſtill, however, it is but very weak. This operation is performed by caſting copper filings on nitre in fuſion in a large crucible, in order that their parts may be as much as poſſible in contact with each other. When the metal becomes very hot, a ſlight motion is obſerved, with faint ſparklings. The reſidue is a browniſh grey oxide, mixed with potaſh; it is waſhed; the water takes up the alkali, which ſtill retains a little copper, and the oxide of the metal remains pure. It melts alone into a deep brown opaque glaſs; it is uſed to colour enamels. It is thought that the alkali is rendered cauſtic; but more experiments are neceſſary to aſcertain this.

Copper very readily decompoſes ammoniacal muriate. Bucquet, who examined this decompoſition with very great care, obtained, on making the experiment in a pneumato-chemical apparatus with mercury, from two drams of copper filings, and a dram of ammoniacal muriate,—fifty-eight inches of elaſtic fluid; of which twenty-ſix inches were very pure ammoniac, twenty-ſix inches detonating inflammable gas, and the remaining

ſix

ſix inches a mephitic gas, which extinguiſhed lights, without being abſorbed by water, or precipitating lime-water; and was conſequently gas azote, produced by the decompoſition of a part of the ammoniac. There was a little liquid ammoniac diſengaged, of a fine colour, which ſtood immediately over the mercury. The reſidue was a blackiſh green maſs, one half of which was diſſolved in the water, and communicated to it a fine colour, the diſtinguiſhing characteriſtic of muriate of copper: the other half was a kind of brown oxide of copper, formed by the water of the ammoniacal muriate. On repeating this decompoſition on four ounces of copper to two of ammoniacal muriate, with the common apparatus of a balloon, Bucquet obtained two drams and eighteen grains of blue liquid ammoniac, which gave a ſlight effervescence with acids, and contained about an inch of carbonic acid to the dram. He knew not how to account for the appearance of this laſt gas: but I ſuppoſe it might proceed from ſome impurities of the ſal ammoniac; for on repeating the experiment with ammoniacal muriate, previouſly purified by ſublimation, the ammoniac which I obtained was very cauſtic, and did not effervesce in the ſmalleſt degree with acids. Oxide of copper likewiſe decompoſes ammoniacal muriate, and communicates to the ammoniac which it diſengages a portion of carbonic acid, that renders it effervescent. This alkali is always blue, becauſe it takes off with it a ſmall portion of oxide of copper, which colours it. Acids, however, do not precipitate an atom of the metal. There are two medicines prepared in pharmacy with ammoniacal muriate and copper; the former of which has received the name of *cupreous*

reous ammoniacal flowers, or *ens veneris*. This is nothing but ammoniacal muriate, coloured by a little oxide of copper. A mixture conſiſting of eight ounces of this ſalt, with a dram of oxide of copper, is ſublimated in two earthen pots, the one placed over the other. All the ammoniacal muriate is volatilized without being decompoſed; and it carries off with it a little oxide of copper, which communicates to it a bluiſh colour. The ſecond, called *celeſtial water*, is prepared by putting an ounce of ammoniacal muriate, with a pound of lime-water, into a copper baſon, and ſuffering the mixture to ſtand in it for ten or twelve hours. The lime diſengages the ammoniac, which diſſolves a little of the copper of the baſon, and by that means acquires a blue colour. Celeſtial water may be made in a glaſs, or an earthen veſſel, by adding a ſmall quantity of filings, or oxide of copper, to the lime-water and ammoniacal muriate.

It appears, that copper decompoſes aluminous ſulphate; for when a ſolution of this ſalt is boiled in a copper veſſel, there is a little aluminous earth precipitated: And when this alumine is precipitated by ammoniac, the earth aſſumes a blue colour, which indicates the preſence of copper. This effect may be likewiſe aſcribed to the exceſs of acid, which aluminous ſulphate always contains.

Hydrogenous gas does not act upon copper, but reduces the oxides of copper, by robbing them of their oxigene; with which principle hydrogene has a greater affinity than copper has.

This metal combines very readily with ſulphur. The combination may be effected in the humid way; that is, by mixing flowers of ſulphur with copper filings moiſtened with water; but it ſucceeds much ſooner in the

the dry way. To accompliſh it in this way, a mixture, conſiſting of equal parts of ſulphur in powder and copper filings, is expoſed to fire in a crucible, which is gradually heated till it become red-hot; from this combination there reſults a blackiſh grey maſs, a ſort of *mat* of copper, which is brittle, and more fuſible than copper. This compound is prepared for dyeing, and for painting Indian ſtuffs, by laying in a crucible alternate ſtrata of copper and ſulphur in powder, and heating the crucible in the manner above mentioned. The mat thus formed is pulverized, and receives the name of *æs veneris*. Alkaline ſulphures and ſulphurated hydrogenous gas, act in a ſufficiently eminent manner on copper. The former ſubſtances diſſolve this metal, either by the dry or by the humid way: the latter communicates an high colour to its ſurface; but the mutual effect of theſe ſubſtances and copper have not been farther examined.

Copper forms an alloy with various metals; with arſenic it becomes white and brittle, and ſo forms *white tombac*.

It combines with biſmuth; forming with it, according to Gellert, a reddiſh white alloy, with cubic facets.

It enters very readily into union with antimony, forming with it the *cupreous regulus* diſtinguiſhed by a beautiful violet colour. It decompoſes ſulphure of antimony, and combines with the ſulphur which it detaches from the ſemi-metal.

With zinc it combines very readily. This combination may be effected in two ways; 1. By fuſion, a metal is obtained of the colour of gold, much leſs liable

to

to ruſt than pure copper, but at the ſame leſs ductile. The more this metal reſembles gold, the brittler it is: beſides, its nature varies according to the proportion in which the two ſubſtances are mixed together, and the precautions taken in melting them: its varieties are ſimilar, pinchbeck, Prince Rupert's metal, and Manheim gold. 2. By cementing plates of copper with native oxide of zinc, or lapis calaminaris reduced to powder and mixed with coal, and making the crucible in which they are contained red-hot; the copper then forms *yellow braſs*. This laſt compound is not ſo liable to ruſt as copper: it is equally malleable, and more fuſible; but if expoſed for ever ſo ſhort a time to a ſtrong heat, it loſes its zinc, and becomes red copper again.

Copper combines with mercury, but not readily; yet by triturating very thin leaves of copper with mercury, theſe metals may be formed into a ſort of amalgam. A plate of this metal, immerſed into a ſolution of mercury by an acid, takes a fine ſilver colour, owing to the mercury being reduced and precipitated by the copper, which has a greater affinity than mercury with oxigene.

Copper and lead combine very well by fuſion; as appears by the formation of the loaves of eliquation.

It is combined with tin in two ways; either by pouring melted tin on the ſurface of a plate of copper, or by melting the two metals together. The former operation is uſed in tinning copper; the latter forms bronze. Copper veſſels to be tinned, are firſt well ſcoured, to render the ſurface on which the tin is to be applied

plied ſmooth and bright. They are next rubbed with ammoniacal muriate, to make them perfectly clear. They are then made hot, and powdered roſin is caſt upon them. This ſubſtance covers the ſurface of the copper ſo as to prevent it from being oxidated. At laſt the melted tin is poured on, and ſpread over it. Complaints have been made, and with good reaſon, that the tinning of copper veſſels is not ſufficient to defend them from the action of air, of moiſture, and of ſalts; becauſe ſuch veſſels are often obſerved to be covered with verdigris. This might be effectually remedied by laying on a thicker coat of tin, were there not reaſon to fear that when ſuch veſſels are expoſed to any degree of heat above that of boiling water, the tin is then liable to be melted, and thus to expoſe the ſurface of the copper uncovered. To prevent ſuch an accident, the tin may be alloyed with iron, ſilver, or platina, to render it harder and leſs fuſible, in order that it may be laid in thicker layers on the copper. Mixtures of this kind are already made uſe of in ſeveral manufactories. It is amazing how ſmall a quantity of tin is ſufficient to tin copper; for Meſſrs Bayen and Charlard have aſcertained, that a pan nine inches in diameter, and three lines in depth, gained only an additional weight of one and twenty grains by being tinned. This trifling quantity, however, is ſufficient to prevent the danger which might otherwiſe ariſe from the uſe of copper veſſels, when care is taken not to ſuffer ſubſtances capable of diſſolving tin to remain too long in ſuch veſſels, and eſpecially to renew the tinning frequently, as friction, heat, and the action of the ſpoons uſed in ſtirring ſubſtances boiled in them, very ſoon deſtroy the tinning.

ning. There is one thing, however, reſpecting the tin uſed by copperſmiths for tinning pans, which we cannot be too much on our guard againſt. It is often alloyed with one fourth-part of lead; the bad effects of which are to be feared, as lead is well known to be very ſoluble in fats and acids. Government ſhould therefore take meaſures to prevent copperſmiths from being cheated when they purchaſe their tin, and from employing the tin of Malacca or Banca, in any other ſtate but as it comes from the Eaſt Indies, before being melted again, and having its purity debaſed by our tin-workers.

M. de la Folie, a citizen of Rouen, who merits the reſpect of the public for thoſe chemical reſearches which he has proſecuted on matters relative to the arts, and for the uſeful diſcoveries with which he has enriched dyeing, pottery, and many other of the manufactures carried on at Rouen; has propoſed, in order that the inconveniences and dangers attending the uſe of tinned copper may be avoided, to employ, in its ſtead, iron plated with zinc; which, as we have already ſeen, is productive of no dangerous effects. Many people have already adopted the uſe of ſuch veſſels with advantage; and it is to be wiſhed, that they were in general uſe.

Tin melted with copper gives a metal, the ſpecific gravity of which is greater than that of either of the two metals of which it is made up, in conſequence of their mutually penetrating each other in a very intimate manner. The greater the proportion of tin in this mixture, ſo much the more white, brittle, and ſonorous, is the mixture. When very white, it is called *bell-metal:*

when

when it contains more than an equal proportion of copper, it is yellow, and bears the name of *bronze*, or *braſs*. It is moulded into ſtatues and into cannons, which muſt be ſo ſolid as not to burſt by a moderate force; and at the ſame time not ſo ductile as to loſe their form by the impulſe of bullets.

Copper and iron may be united by fuſion or by ſoldering. This combination, however, does not very eaſily ſucceed. When a mixture of theſe two metals is melted in a crucible, the iron is found to be often intermixed, but not perfectly united with the copper. Copper decompoſes the mother water of ſulphate of iron; and yet iron has a greater affinity than acids with copper.

The uſes to which copper is applied are very various, and very well known. A great variety of utenſils are made out of it. Yellow copper, or an alloy of copper with zinc, is principally employed for ſuch purpoſes, on account of its ſuperior ductility and beauty. Copper being a very violent poiſon, ſhould never be adminiſtered as a medicine. The remedies moſt uſually applied in the caſe of poiſoning by copper reduced to oxide or verdigris, are emetics, water drunk in large quantities, alkaline ſulphures, alkalis, &c.

Sulphate of copper contains in the hundred weight 30 *lib.* of acid, 43 *lib.* of water, and 27 *lib.* of copper.

M. Chaptal obtained from a ſolution of copper in the nitric acid, by ſlow ſpontaneous evoporation, *white* rhomboidal cryſtals, which decrepitated upon the coals, emitted by heat, a red gas, and left a grey oxide. H.

CHAP.

CHAP. XX

Of Silver.

SILVER, called *Luna*, or *Diana*, by the alchemiſts, is a metal of a white colour, and the moſt lively brilliancy. It has neither taſte nor ſmell. Its ſpecific gravity is ſuch, that it loſes in the hydroſtatic balance about one-eleventh part of its weight. A cubic foot of this metal weighs ſeven hundred and twenty pounds. So great is the ductility of ſilver, that it may be reduced to leaves as thin as paper, and to threads finer than hairs. A grain of ſilver may be extended ſo as to contain an ounce of water. Its tenacity is ſo conſiderable, that a wire of ſilver, one tenth of an inch in diameter, is ſufficient to ſupport the weight of two hundred and ſeventy pounds without breaking. It poſſeſſes hardneſs and elaſticity in an inferior degree to that in which copper poſſeſſes theſe qualities; it is, next after copper, the moſt ſonorous of all metals. It becomes hard under the hammer, but may be eaſily deprived by heating of the hardneſs which it thus acquires.

Meſſrs Tillet and Mongez have cryſtallized ſilver. They obtained it in quadrilateral pyramids, ſometimes ſolitary on the edges of the crucible, at other times laterally united in groups.

Silver is found in various ſtates in nature. The following are the ſilver ores moſt ſtrikingly diſtinguiſhed from each other.

1. Native or virgin ſilver. It is known by its luſtre and ductility. It appears under an amazing variety of forms. It is frequently in irregular maſſes, the ſize of which is more or leſs conſiderable. It is ſometimes in capillary threads twiſted round; its formation then appears to be owing to the decompoſition of a red ſilver ore, as has been obſerved by Henckel and M. Romé de Lille. It is likewiſe found in plates, or in pieces of network reſembling ſpiders webs, which the Spaniards on this account call *aranè;* ſometimes again in a vegetable form, or in branches conſiſting of octohædrons riſing one over another. Some of theſe ſpecimens reſemble the fern-leaf, others are ſeparate cubes and octohædrons, with truncated angles; but theſe laſt are rare. Native ſilver is often diſperſed in a quartzoſe gangue; it is ſometimes found in fat earths. It is found in Peru, in Mexico, at Konſberg in Norway, at Johan Georgenſtadt and Ehrenfriederſdorf in Saxony, at St Marie, at Allemont in Dauphiny, &c. This metal is not known to exiſt in nature in the ſtate of oxide.

2. Native ſilver, in union with gold, copper, iron, antimony, or with gold and copper together, or with arſenic and iron together. Theſe various native combinations of ſilver are found at Freyberg in Saxony,

and in the mines of Guadal-Canal in Spain. But it is to be obſerved, that the proportion of the extraneous ſubſtances is very trifling.

3. *Vitreous ſilver ore* conſiſts, according to moſt mineralogiſts, of ſilver and ſulphur. It is of a blackiſh grey colour like lead; it is alſo brown, greeniſh, yellowiſh, &c. and it may be cut with the knife as well as that metal. It is frequently irregularly ſhaped, ſometimes in octohædral cryſtals, the angles of which are truncated. M. Monnet takes notice of a variety, which, inſtead of being diviſible by the knife, falls into powder. This ore affords from ſeventy-two to eighty-four pounds of ſilver in the hundred weight. It melts very eaſily: when expoſed to a heat ſo moderate as not to melt it, the ſulphur is diſſipated, and leaves the virgin ſilver in a vegetative form, or in filaments.

4. *Red ſilver ore* is often of a deep colour, ſometimes tranſparent, and cryſtallized in cubes, with their edges truncated, or in hexahædral priſms, terminating in trihædral pyramids; at Potoſi this is called *roſſi-clero*. The ſilver is combined in it with ſulphur and arſenic. When it is broken, its colour is lighter within, and it appears to conſiſt of ſmall needles or priſms, converging like ſtalactites. If expoſed, with proper management, to a fire ſtrong enough to make it red-hot, the ſilver is reduced, and takes a capillary vegetative form, like native ſilver. It affords from fifty-eight to ſixty-two pounds of ſilver in the hundred weight. This ſpecies is diverſified into varieties, by the properties of colour, form, and gravity, &c. It is generally found in all ſuch plates as contain the other ſilver ores.

5. Silver

5. Silver with arſenic, cobalt, and iron mineralized by ſulphur. Bergman ſays, that in this ore the ſilver is ſometimes above the proportion of $\frac{50}{100}$. This ore is ſometimes grey and ſparkling, ſometimes of a dark and duſky appearance; efflorescences of cobalt are obſervable upon it. The ſilver ore called *gooſe-dung* belongs to this ſpecies.

6. The grey ſilver ore, which differs from the copper ore called *Fahlertz* only in containing a larger proportion of this precious metal. It is either in maſſes or in triangular cryſtals, with their ſides cut ſloping. The largeſt of theſe cryſtals are not of a very bright colour; the ſmall, being diſperſed over a ſmooth gangue, are of ſo lively a luſtre as to afford a very pleaſing ſpectacle when light falls upon them. Grey ſilver affords from two to five marks of ſilver in the hundred weight. Grey ſilver is ſometimes introduced into organic matters, and moulded into an exact imitation of their form. It is then called *figured ſilver ore*. Of this kind is that reſembling blades of corn, and that which M. Romé de Lille has obſerved in the form of the cones and ſcales of the pine-tree. This ore contains ſilver, copper, iron, arſenic, and ſulphur. When the proportion of the iron is very ſmall, it is then called *white ſilver ore*. This latter ore is not to be confounded with galena containing ſilver, which is ſometimes called by the workmen *ſilver ore*.

7. Black ſilver ore, called by the Spaniards *nigrillo*, is, according to Meſſrs Lehman and Romé de Lille, nothing but red or grey ſilver ore decompoſed, and brought into a kind of middle ſtate between its original ſtate and that of native ſilver: it is ſometimes found to con-

tain native ſilver. The latter of theſe two mineralogiſts has obſerved, that when ſolid, ſpongy, or worm-eaten, it may be conſidered as produced from the red and vitreous ores, and is then richer than when friable and pitch-coloured; when it may be conſidered as originating from the alteration of grey or white ſilver ores. It therefore affords various products. In general, it affords from ſix or ſeven to nearly ſixty pounds of ſilver in the hundred weight.

8. *Corneous ſilver ore*, or the natural combination of ſilver with muriatic acid, and a little ſulphuric acid, is a pearl-grey, a violet-grey, or a yellowiſh grey; ſometimes, though but ſeldom, it is ſemi-tranſparent: it is ſoft, and may be eaſily cruſhed or cut: it melts at the flame of a taper. It is found in cubic cryſtals, but oftneſt in irregular maſſes. It frequently contains lumps of native ſilver. It was formerly thought to contain ſulphur and arſenic; but mineralogiſts have now agreed in reſpect to its nature. Meſſrs Cronſtedt, Lehman, and Sage, Woulfe, Lommer, and Bergman, have found it to contain muriatic acid, which is diſengaged by heat. Woulfe has beſides aſcertained, that it contains ſulphuric acid. It is found at Saxony, at St Marie, at Guadal-Canal in Spain, and at Allemont in Dauphiny.

9. *The ſoft ſilver ore* of Wallerius, is ſilver either native or mineralized, and intermixed with more or leſs coloured earth. Earths containing ſilver vary in colour from a dirty grey to a deep brown.

10 Laſtly, Silver is often found in combination with other metallic matters in ores, the hiſtory of which we have already given. Such are miſpickel, the grey cobalt

balt ore, kupfernickel, or nickel ore, ſulphure of antimony, which often affords the variety called *ſilver ore in feathers*, *blende*, *galena*, *martial pyrites*, and *white copper ores*: the latter are only grey ſilver ores. All of theſe ſubſtances, many times, contain ſo much ſilver as renders the working them for the ſake of this precious metal profitable. But it is eaſy to ſee, that they cannot, with any propriety, be deſcribed as peculiar ſilver ores; and deſerve only to be mentioned as containing ſilver.

Silver ores are aſſayed in various ways, according to the nature of the ore. All that is ſtrictly requiſite in aſſaying ſuch as contain native ſilver, is to pound and waſh them. In order to ſeparate the metal entirely from extraneous ſubſtances altering it; after being waſhed, it may be triturated with running mercury. The mercury diſſolves the ſilver, and being then volatilized by fire, leaves the perfect metal ſeparate. Sulphureous ſilver ores need to be roaſted, and afterwards melted with a greater or a leſs quantity of flux. The ſilver obtained by this melting is commonly alloyed with lead, copper, iron, &c. To ſeparate it, and to aſcertain exactly what quantity of the precious metal this mixture contains, a proceſs entirely chemical, and founded on the conſideration of the properties of the imperfect metals, is employed. As lead is ſuſceptible of vitrification, and acts in the quality of a flux on the imperfect metals, ſuch as iron and copper, but is incapable of affecting ſilver in the ſame manner; lead is therefore employed to ſeparate the perfect metal from ſuch imperfect metals as alter it. The greater the proportion of the extraneous matters by which the ſilver is alter-

ed, ſo much the more lead muſt be made uſe of to ſeparate them. This alloy is put into flat porous veſſels, made of calcined bones and water. Theſe roaſting pots, which are called *cupels*, as being in the form of ſmall cups, are proper for abſorbing the lead-glaſs formed in this operation. The ſilver after this remains pure. In order to determine what quantity of the imperfect metals any maſs of ſilver contains, it is conſidered as conſiſting of twelve parts, which are called *penny-weights;* and each of theſe conſiſts of twenty-four grains. If the maſs of ſilver under examination has loſt in the cupels only the twelfth part of its weight, it is called *ſilver of eleven penny-weights:* if it has loſt but a twenty-fourth part of its weight, it is *ſilver eleven penny-weights and twelve grains fine*, and ſo on. The cupel is found, after this operation, to have acquired a conſiderable addition of weight; it contains vitreous oxide of lead, and of the other imperfect metals, which were in combination with the ſilver, and have been ſeparated by the lead. As the lead almoſt always contains a little ſilver, it muſt be at firſt cupelled by itſelf, in order to aſcertain what quantity of ſilver it contains; from the button of fine ſilver obtained, a deduction muſt be made for the ſmall portion known to be contained in the lead which is employed, and is called a *witneſs*. The cupellation exhibits a phænomenon from which the artiſt underſtands the ſtate of his operation. As the ſilver becomes pure by vitrification, and the ſeparation of the lead, it aſſumes a much more brilliant appearance than that with which the lead is ſtill intermixed. The luſtre by degrees increaſes; and when the whole ſurface of the metal becomes pure and

of

of a dazzling brightneſs,—at the very inſtant when the whole aſſumes ſuch an appearance, the operation is finiſhed. The ſilver, after being thus cupelled, is entirely purified from the imperfect metals which it before contained: but it may ſtill contain gold; and a new proceſs muſt be employed to ſeparate the two perfect metals. As gold is much leſs liable than ſilver to be altered by a great many menſtrua, the ſilver is diſſolved by the nitric or the muriatic acid, and by ſulphur; and the gold, which is ſcarce liable to be affected by theſe ſolvents, remains pure. This way of ſeparating ſilver from gold is called *parting*. We will ſpeak of the various ways of parting theſe metals, after deſcribing in what manner the ſeveral ſolvents which are uſed for this purpoſe act upon the ſilver, and when we treat of the alloy of ſilver with gold.

The proceſſes, in the great way, for extracting ſilver from its ores, and obtaining it pure, are nearly the ſame with thoſe which we have deſcribed as proper for aſſaying the ores of this metal. There are, in general, three modes of treating ſilver in the great way. The firſt conſiſts in triturating virgin ſilver with mercury: this amalgam is waſhed, to purify it entirely from earth: it is then ſtrained through goat-ſkin, and diſtilled in an iron retort; after which, the ſilver is melted, and run into ingots. This proceſs cannot be applied to ſilver ores containing ſulphur. Theſe muſt be roaſted and mixed with lead, in order to refine the precious metal by cupellation. This is the proceſs to which rich ſilver ores are ſubjected. As to ſuch as are poor, the method employed upon them is different from either of theſe two. They are melted without being previouſly roaſted,

with a certain quantity of pyrites. This is called *crude fuſion*, and affords a mat of copper containing ſilver, which is treated with lead by eliquation. The lead which takes up the ſilver as it melts, is afterwards ſcorified in the cupel, and then leaves the perfect metal pure. Cupellation in the great way differs from that which is performed in the ſmall way; for, whereas in the former the ſcorified lead is blown over the edges of the cupel with bellows, in the aſſay the vitrified oxide of lead is abſorbed by the cupel.

The ſilver obtained by the proceſſes which we have deſcribed, is, in general, much leſs liable to alteration than any of the other metals of which we have as yet given the hiſtory. The contact of light, however long the metal remain expoſed to it, produces no change of its properties. Heat melts it, makes it boil, and volatilizes it, but without altering its nature. An heat ſufficient to make it become firſt red, and afterwards white, is requiſite to melt it: it is more fuſible than copper. After being kept for ſome time in fuſion, it ſwells, and exhales vapours, which are nothing but ſilver volatilized. What puts this fact beyond doubt is, that portions of the metal are found in the funnels of chimnies in which it is melted in large quantities. It is confirmed by a fine experiment of the Academicians of Paris; they expoſed very pure ſilver to the focus of M. de Trudaine's lens, and obſerved the melted metal to diffuſe a thick ſmoke, which being intercepted by a plate of gold, was fixed upon it, and whitened its ſurface.

Silver, when ſlowly cooled, is ſuſceptible of a regular form, and cryſtallizes in quadrangular pyramids.

M.

M. Baumé obſerved, that this metal takes, as it cools, a regular form; which appears from its ſurface being covered over with filaments reſembling the threads of a feather. I have remarked, that the button of fine ſilver obtained by cupellation, often exhibits on its ſurface ſmall ſpaces with five or ſix ſides, arranged like the flags of a pavement. But its cryſtallization in tetrahædral pyramids has not been carefully examined by any but Meſſrs Tillet and the Abbé Mongez.

It was long imagined, and many chemiſts are ſtill of opinion, that ſilver is ſecure againſt the joint action of heat and air. It is certain that this metal ſuffers no apparent alteration when held for ſome time in fuſion, and in contact with air. Juncker, however, related, that on treating ſilver for a conſiderable time by reverberation, in the way of Iſaac of Holland, he found it to change into a vitreous oxide. This fact has been confirmed by Macquer. He expoſed ſilver twenty times ſucceſſively in a porcelain crucible, to the heat of the porcelain furnace at Seves, and obtained, by the twentieth fuſion, a vitreous matter, of an olive-green colour, which he conſidered as a true vitreous oxide of ſilver. When this metal is heated in the focus of a burning-glaſs, its ſurface is always covered with a white pulverulent matter, and a greeniſh incruſtation is formed on the body on which it reſts. Theſe facts remove every doubt that could be reaſonably entertained of the alteration of ſilver in ſuch circumſtances. Though much more refractory againſt all attempts to reduce it to an oxide than any other metal, yet is it liable to be at length changed into a white oxide, which, when treated

in a very ſtrong fire, takes an olive-green colour. It might perhaps be poſſible to obtain an oxide of ſilver, by reducing the metal to very thin plates or leaves, and heating it for a conſiderable time in a matraſs, in the ſame way as is done with mercury. The electric ſpark appears likewiſe to oxidate ſilver. It is certain, at leaſt, that this metal has but a very faint tendency to combine with the baſe of vital air, and that heat does not contribute to this combination ſo much as in the caſe of any of the other metals; but, on the other hand, deſtroys it by a very ſlight effort; for all the oxides of ſilver may be eaſily reduced without addition; and oxigene muſt therefore be but very imperfectly combined with the metal, ſince it can be detached from it ſo as to form vital air, by the action of light and heat alone.

Silver is liable to no alteration from air; its ſurface, in a long ſpace of time, is a very little ſullied by the action of the atmoſphere. Water acts not upon it: earthly matters do not combine with this metal: Its oxide, if melted with glaſſes, would probably communicate to them an olive-green colour.

Neither the alkalis nor the ſalino-terrene ſubſtances act in a ſenſible degree on ſilver. The ſulphuric acid, when highly concentrated and boiling, and when the metal is preſented in a ſtate of extreme diviſion, diſſolves it. A conſiderable quantity of ſulphureous acid gas is diſengaged from this ſolution; and the ſilver is reduced to a white matter, on which a new quantity of ſulphuric acid muſt be poured, in order to diſſolve it. By evaporating this liquor, ſulphate of ſilver is obtained in ſmall needles. I have ſeveral times obtained this

ſalt

ſalt in plates, formed by the longitudinal junction of a number of theſe needles. This ſalt melts when expoſed to fire, and is of a very fixed nature. It is decompoſable by alkalis, iron, copper, zinc, mercury, &c. All the precipitates obtained by alkalis may be reduced, without addition, to fine ſilver, in cloſe veſſels.

The nitric acid oxidates and diſſolves ſilver rapidly, even without the help of heat. This ſolution even takes place at times ſo quickly, that to prevent the inconveniences ariſing from this circumſtance, it is found expedient to have the ſilver in lumps when expoſed to the acid. A conſiderable quantity of nitrous gas is diſengaged on the occaſion, and a white precipitate is produced, more or leſs in quantity, if the acid of nitre have been mixed with any portion of ſulphuric or muriatic acid. The nitric acid uſually gives it a blue or a green colour. If the ſilver be pure, it loſes that colour, and becomes tranſparent as ſoon as the ſolution is fully accompliſhed: but if the ſilver happen to contain copper, the ſolution retains a lighter or deeper greeniſh ſhade. The pureſt ſilver that can be obtained often contains gold. In this caſe, as the nitric acid is ſcarce capable of acting on that metal, when it acts on the ſilver it ſeparates ſmall blackiſh flakes, which fall to the bottom of the veſſel, and prove to be gold It is in conſequence of the nitric acid acting in ſo different a manner on theſe two metals, that it is happily employed to ſeparate them in the operation of parting by aquafortis. The nitric acid diſſolves a quantity of ſilver equal to half its own weight. This ſolution is exceedingly cauſtic; ſo much ſo, that it produces black ſpots on the epidermis, and eats entirely through it. When fully eſtimated,

it

it depoſites thin bright cryſtals, like the boracic acid: when half the quantity is evaporated, it affords, by cooling, flat cryſtals, which are either hexagonal, or triangular, or ſquare, and appear to conſiſt of a great many ſmall needles joined laterally. Theſe flat cryſtals are obliquely arranged one over another. They are tranſparent and very cauſtic. They are called *Lunar cryſtals*: their proper name is nitrate of ſilver. This ſalt is ſpeedily altered by the contact of light, and rendered black by combuſtible vapours. When placed on a burning coal, it readily detonizes, leaving after the detonation a white powder, which conſiſts of pure ſilver: it is very fuſible. If expoſed to fire in a crucible, it ſwells at firſt as it loſes the water of its cryſtallization; and after that, remains in fuſion without motion. If ſuffered to cool in this ſtate, it becomes a grey maſs, ſlightly needled; a preparation which is known in ſurgery under the name of *Lapis infernalis*. But there is no occaſion to make uſe of cryſtallized nitrate of ſilver when we wiſh to obtain this medicine; the proceſs by which it is made up is too tedious, and too expenſive. It is ſufficient to evaporate to dryneſs a ſolution of ſilver by the nitric acid, to put the reſidue in a ſilver crucible or ladle, as M. Baumé adviſes, and to heat it ſlowly till it melt: it may be then run into a mould, to give it the form of ſmall cylinders. When theſe cylinders are broken, they appear to conſiſt of needles diverging in radii from the centre of the cylinder, and terminating at its circumference. In compoſing the *infernal ſtone* of nitrate of ſilver, we muſt beware of heating it too long; otherwiſe a part of the ſalt will be decompoſed, and formed into a button at the bottom of the

the crucible. In order to have an opportunity of obſerving what paſſes in this operation, I diſtilled this ſalt in a pneumato-chemical apparatus; I obtained nitrous gas and vital air, mixed with azotic gas. In my matraſs I found the ſilver entirely reduced; the glaſs was become opaque, like enamel, and was of a beautiful cheſnut-brown colour. The brown colour which the glaſs takes on this occaſion muſt, no doubt, be owing to oxide of manganeſe, or ſome other ſubſtance contained in it; for the colour of glaſs formed of oxide of ſilver is nearly an olive green, as we have already obſerved.

Nitrate of ſilver does not attract moiſture when expoſed to the air; it diſſolves very readily in water; and may be cryſtallized from the ſolution by a ſlow evaporation of the fluid.

The nitric ſolution of ſilver is decompoſed by ſalino-terrene ſubſtances and alkalis; but the phænomena vary greatly, according to the ſtate of theſe matters. Lime-water produces a very copious olive-coloured precipitate. Fixed alkali, ſaturated with carbonic acid, makes it yield a white precipitate: cauſtic ammoniac cauſes it to afford a grey precipitate, inclining to olive-green. This precipitation does not take place till a conſiderable time after the two ſubſtances have been mixed.

Although the nitric acid act with a ſtronger energy on ſilver than any of the other acids, there are, however, others which have a greater affinity with its oxide, and adhere to it with more obſtinacy: the ſulphuric and the muriatic acids detach the oxide from the nitric acid. For this reaſon, when a few drops of either of theſe acids are poured

poured into a nitric ſolution of ſilver, a precipitate is produced; which, when the ſulphuric acid is employed, is a white powder; and when it owes its origin to the muriatic acid, is in thick flakes like a *coagulum*. In the former caſe, the precipitate is ſulphate of ſilver; in the latter, muriate of ſilver. As neither of theſe two ſalts is very liable to ſolution, they therefore ſubſide in a precipitate. It is not neceſſary that the acids be in a ſtate of liberty when applied to this purpoſe; the neutral ſalts, which are formed by their combinations with alkalis and ſalino-terrene ſubſtances, ſerve the purpoſe equally well. A double decompoſition and a double combination then take place; for the nitric acid, ſeparated from the ſilver, enters into combination with the baſe of the ſulphuric or muriatic ſalt.

On this difference among the acids, in reſpect to the manner in which they act upon ſilver, there is founded a proceſs which is employed to procure the nitric acid in an high ſtate of purity, and unmixed with any other acid: in a word, in that ſtate in which it is requiſite to have it for many operations in metallurgy, and for moſt chemical experiments. Diſtilled ſpirit of nitre is generally mixed with a certain quantity of ſulphuric or muriatic acid; and chemiſts have therefore induſtriouſly ſought to ſeparate theſe extraneous fluids, and have found no happier expedient than the uſe of the nitric ſolution of ſilver. This ſolution is poured into the impure nitric acid till it ceaſe to produce a precipitate; the ſediment of ſulphate or muriate of ſilver is ſuffered to ſettle; the acid is decanted off, and diſtilled by a moderate heat, to ſeparate from it that ſmall quantity of ſalts of ſilver which may ſtill be contained in it. The pro-

duct

duct of this diſtillation is very pure nitric acid: in the arts it is called *precipitated aquafortis.*

Moſt metallic matters are capable of decompoſing the nitric ſolution of ſilver, as they have in general a greater affinity than that metal with oxigene. Arſeniate of potaſh, diſſolved in water, produces in the nitric ſolution a reddiſh precipitate, which originates from the union of the ſilver with the arſenic acid. This precipitate reſembles red ſilver ore. The ſilver may be obtaintained in its metallic ſtate, as a precipitate from this ſolution, by moſt of the metals and the ſemi-metals. But the ſeparation of this perfect metal by mercury and copper is particularly worthy of our notice, on account of the phænomena which attend the firſt of theſe metallic ſubſtances, as it acts on ſilver, and the uſeful purpoſes which are ſerved by bringing the ſecond to act upon it.

Silver, when ſeparated from the nitric acid by mercury, is in a metallic ſtate; and the precipitate ſubſiding ſlowly, produces, as it ſubſides, a regular figure, known by the name of *Diana's tree*, or *the philoſophic tree.*— This ſpecies of cryſtallization may be obtained by ſeveral different proceſſes. Lemery directed to take an ounce of fine ſilver, to diſſolve it in nitric acid moderately ſtrong, and to dilute the ſolution with about twenty ounces of diſtilled water, adding two ounces of mercury. In the ſpace of forty days a very beautiful vegetative form is produced. Homberg gives another proceſs, much ſhorter than this. His proceſs is, to make a cold amalgam of four drachms of ſilver in leaves, with two drachms of mercury: this amalgam is to be diſſolved in a ſufficient quantity of nitric acid, and a pound and an half of diſtilled water to be added to the ſolution: into

an

an ounce of this liquor put a ſmall ball of a ſoft amalgam of ſilver, and the precipitation of ſilver will immediately take place. The ſilver being precipitated and combined with a part of the mercury, is depoſited in a kind of priſmatic filaments on the ſurface of the amalgam. Other filaments riſe above the firſt, ſo as to preſent a kind of vegetation in the form of a buſh. Laſtly, M. Baumé has deſcribed a way of obtaining a tree of Diana, a little different from Homberg's proceſs, and more infallibly attended with ſucceſs. He directs to mix ſix drachms of the ſolution of ſilver, and four drachms of a ſolution of mercury, by the nitric acid, both fully ſaturated; to add to the mixture five ounces of diſtilled water; and then to pour it into an earthen veſſel, upon ſix drachms of amalgam, made up of ſeven parts of mercury, with one of ſilver. Either of theſe proceſſes ſucceeds in a much ſhorter time than Lemery's, in conſequence of the relation ſubſiſting between the metallic matters and their mutual action. In fact, the mercury contained in the ſolution attracts the mercury of the amalgam; the ſilver of the amalgam acts in the ſame way on the ſilver of the ſolution: and of conſequence the ſilver is more ſpeedily precipitated. The mercury of the amalgam, being more than is requiſite to precipitate the ſilver of the ſolution, produces a third effect, which we muſt not ſuffer to eſcape unnoticed: It attracts the ſilver by its affinity and tendency to combine with that metal: a combination is actually effected between them; for the vegetation of the tree of Diana is a real amalgam, brittle and cryſtallized. This cryſtallization ſucceeds much better in conical veſſels, ſuch as glaſſes, than in round or wide veſſels, like the cucurbite recommended

commended by M. Baumé. It is almoſt unneceſſary to mention, that the veſſel muſt not be moved, nor expoſed to any impulſe which might hinder the regular ſymmetrical arrangement of the amalgam.

Copper immerſed into a ſolution of ſilver likewiſe precipitates it in a bright metallic form. This is the proceſs uſually employed to ſeparate ſilver from its ſolvent, after the operation of parting. Plates of copper are dipped into the ſolution, or rather the ſolution is put into a copper veſſel; the ſilver is immediately ſeparated in whitiſh grey flakes. When the liquor becomes blue, and ceaſes to precipitate ſilver, it is decanted off. The ſilver precipitated is repeatedly waſhed, then melted in crucibles, and paſſed with lead into a cupel, to ſeparate from it a portion of copper, which became united with it in the precipitation. The ſilver which paſſes through this operation is purer than any other kind: it is no leſs than twelve penny-weights fine. From theſe two caſes of the precipitation of ſilver by mercury and by copper, it appears that metals ſeparated from their ſolvents by metallic matters, are precipitated with all their properties. This phænomenon, as we have ſhown in the hiſtory of copper, takes place in conſequence of the metals immerſed into the ſolution of ſilver, robbing it of its oxigene, with which they have a greater affinity.

The muriatic acid does not diſſolve ſilver immediately; but it diſſolves its oxide readily enough. This acid, ſuperſaturated with oxigene, eaſily oxidates the metal. Such, no doubt, is the reaſon of what happens in the *concentrated parting*. This operation conſiſts in expoſing to fire, plates of gold alloyed with ſilver, cemented with

a mixture of ſulphate of iron and muriate of ſoda: The ſulphuric acid, diſengaging the muriatic, communicates to it a portion of its own oxigene; and the muriatic acid then acts upon the ſilver, and diſſolves it.

There is a much eaſier and more expeditious proceſs for combining the muriatic acid with oxide of ſilver. The acid is poured into a nitric ſolution of the metal: a very copious precipitate is inſtantaneouſly formed, and proves to be a combination of the muriatic acid with ſilver; for the metal has a greater affinity with the muriatic than with the nitric acid, and of conſequence forſakes the latter to combine with the former. The ſame combination may be obtained by pouring muriatic acid into a ſolution of ſulphate of ſilver; for this acid has likewiſe a greater affinity than the ſulphuric with the metal. The muriatic acid may alſo be combined with ſilver, by heating the acid with oxide of the metal precipitated from the nitric acid by fixed alkali.

Muriate of ſilver poſſeſſes various properties worthy of notice. It is remarkably fuſible. When expoſed in a phial to a moderate heat, ſuch as that of hot aſhes, it melts into a grey ſemi-tranſparent ſubſtance, bearing no ſmall reſemblance to horn; and for this reaſon called *luna cornea*. If run upon a ſurface of porphyry, it fixes into a friable matter, appearing to be cryſtallized in fine ſilver needles. When long heated in contact with air, it is decompoſed; it paſſes eaſily through the crucibles; one part of it is volatilized, and another reduced to metal; ſo that it now takes the form of ſilver globules diſperſed through muriate of ſilver; a portion of the ſalt remaining not decompoſed. This ſalt, when

expoſed

" expoſed to light, loſes its whiteneſs, and becomes ſpeedi-
" ly brown. It diſſolves in water; but, according to an experiment of M. Monnet's, a pound of diſtilled water diſſolves only three or four grains. Alkalis are capable of decompoſing muriate of ſilver, when it is either diſ-
" ſolved in water, or expoſed to fire, together with any of theſe ſalts. This is one way of obtaining the fineſt and pureſt ſilver poſſible. Mix, for this purpoſe, four parts of potaſh, or carbonate of potaſh, with one of muriate of ſilver: Put the mixture into a crucible, and melt it; when it is completely melted, take it out of the fire; ſuffer it to cool, and then break it: ſeparate the ſilver; which is found under the muriate of potaſh formed during this operation, and the exceſs of alkali. M. Baumé, to whom we owe this proceſs, aſſerts, that the quantity of alkali which he directs to be employed, hinders the muriate of ſilver from paſſing through the crucible, by acting on all its parts, and decompoſing them at once. Margraff has given another proceſs for reducing this ſalt, and obtaining from it ſilver perfectly pure. Triturate in a mortar five drachms and ſixteen grains of muriate of ſilver, with an ounce and an half of ammoniacal carbonate, and as much diſtilled water as may be ſufficient for making it into a paſte: ſtir this mixture till the ſwelling and effervescence which at firſt take place in it ceaſe: then add three ounces of pure mercury, and triturate the whole till it be formed into a beautiful amalgam of ſilver: waſh it with a good quantity of water; continue the trituration, and repeat the waſhing till the water run off very clear, and the amalgam become very bright: then dry the amalgam, and diſtil it in a retort till the veſſel take a white red colour: the

mercury now paſſes into the receiver, and the ſilver is found in an high ſtate of purity at the bottom of the retort. In this manner the metal may be obtained of the higheſt purity poſſible, and without any ſenſible loſs. This ſort of ſilver ſhould be uſed in nice chemical experiments. The water employed to waſh this mixture carries off two ſubſtances; a certain quantity of ammoniacal muriate, which it holds in ſolution, and a white powder not ſoluble in water. When the white powder is ſublimated, there is a ſmall quantity of ſilver found at the bottom of the ſublimatory veſſel. This experiment proves, that muriate of ſilver cannot be completely decompoſed otherwiſe than by double affinity. In fact, in Margraff's proceſs, the cauſe of the ammoniac combining with the muriatic acid is, that the ſilver is firſt detached from the acid by the mercury, and the alkali then becomes capable of effecting an event which it could not otherwiſe have produced. But this tedious and expenſive operation can only be employed in the ſmall way, and in the laboratory. To reduce a great quantity of muriate of ſilver at once, either fixed alkali, or ſome metallic ſubſtance having a greater affinity than ſilver with the muriatic acid, muſt be employed. Such, among others, are antimony, lead, tin, iron, &c. One part of muriate of ſilver melted in a crucible, with three parts of any of theſe matters, affords, at the bottom of the crucible, the ſilver reduced and ſeparate; while the metal employed to produce the ſeparation appears in union with the muriatic acid. The ſilver precipitated in this manner is very impure; it always contains more or leſs of the metal employed to ſeparate it; and as, in compliance with the advice of Kunckel, lead

is moſt commonly employed for the purpoſe, this ſilver needs to be cupelled; nor can it even be rendered equally pure with that which is reduced by alkalis, or by Margraff's proceſs.

The nitro-muriatic acid acts with conſiderable force on ſilver; and, as it diſſolves it, cauſes it to precipitate. The manner in which this effect takes place may be eaſily underſtood: the nitric acid diſſolves the metal at the firſt, and the muriatic acid, detaching itſelf from the nitric, forms a neutral ſalt with the ſilver; which, having no great tendency to ſolution, is depoſited in ſediment. This proceſs may be uſed to ſeparate ſilver from gold.

We know but little about the manner in which the other acids act upon ſilver; only, a ſolution of borax produces in the nitric ſolution of this metal a very copious white precipitate; which precipitate conſiſts of boracic acid in union with oxide of ſilver.

This metal does not appear liable to be altered by neutral ſalts. It is certain, at leaſt, that it does not detonize with nitre, nor decompoſe ammoniacal muriate. Silver, in conſequence of its being unalterable by nitre, may be eaſily ſeparated from imperfect metals, ſuch as copper, lead, &c. by detonizing them with that ſalt. This metal, alloyed above the juſt proportion with ſome of the baſer metals, is melted with nitre: the ſalt detonizing burns the imperfect metal; and the ſilver falls to the bottom of the crucible in a ſtate of much higher purity.

Almoſt all combuſtible matters act with more or leſs force on ſilver. No metal is ſooner tarniſhed or coloured by inflammable matters. Sulphurated hydrogenous

gas, from whatever ſubſtance diſengaged, communicates to ſilver, the inſtant it comes into contact with it, a blue or violet colour, inclining to black, and conſiderably diminiſhes its ductility. It is known that fœtid animal vapours, ſuch as proceed from houſes of office, from putrefied urine, and from hot eggs, produce the ſame effect on this metal. The mutual action of theſe bodies, and the combination which takes place on the occaſion, have not yet been examined.

Sulphur combines very readily with ſilver. This combination is uſually effected by ſtratifying on a crucible plates of the metal with flowers of ſulphur, and melting the mixture haſtily: the reſult is a violet black maſs, much more fuſible than ſilver, brittle, and needled; in a word, a true artificial ore. This compoſition is eaſily decompoſed by the action of fire, on account of the volatility of ſulphur, and the fixity of ſilver: the ſulphur is conſumed and diſſipated, leaving the ſilver pure. Alkaline ſulphure diſſolves this metal in the dry way: on melting one part of ſilver with three of ſulphure of potaſh, the metal diſappears, and may be diſſolved in water together with the ſulphure. An acid poured into the ſolution produces a black precipitate of ſulphurated ſilver. Leaves of ſilver put into a ſolution of ſulphure of potaſh ſpeedily take a black colour; and it appears that the ſulphure forſakes the alkali, to unite with the metal and mineralize it; as we have already obſerved of mercury.

Arſenic combines with ſilver, and renders it brittle. We know not yet how the acid of arſenic affects this metal.

It

It combines, but not without great difficulty, with cobalt.

It enters readily enough into an alloy with biſmuth, forming with it a brittle mixed metal, the ſpecific gravity of which is greater than that of either of the two metals taken ſeparately. According to Cronſtedt, ſilver does not unite with nickel. Theſe metals, when melted together, are diſpoſed ſeparately, one beſide the other, as if their ſpecific gravities were preciſely equal.

It melts with antimony into a very brittle alloy. It appears to be capable of decompoſing ſulphure of antimony, by combining with the ſulphur of that mineral, with which it has a greater affinity than antimony has.

Silver eaſily combines with zinc by fuſion. From this combination there reſults an alloy granulated at the ſurface, and very brittle.

In mercury, even cold, it is completely diſſolved. All that is neceſſary to effect this ſolution, is to malaxate leaves of ſilver with this metallic fluid: an amalgam is by this means inſtantaneouſly produced; the conſiſtency of which varies with the reſpective quantities of the two ſubſtances. This amalgam may be brought into a regular form by fuſion and ſlow evaporation: it affords tetrahœdral priſmatic cryſtals, terminating in pyramids of the ſame form. The mercury becomes in ſome degree fixed in this combination: for, to ſeparate it from the ſilver, a ſtronger heat is required than what is ſufficient to volatilize it when taken by itſelf. Silver decompoſes corroſive mercurial muriate, either in the dry or in the humid way.

It unites perfectly with tin: but entirely loſes its duc-

tility when alloyed with ever ſo ſmall a proportion of that metal.

It enters readily into union with lead, which renders it very fuſible, and deſtroys its elaſticity and ſonorouſneſs.

It forms an alloy with iron, which might perhaps be very advantageouſly employed in the arts.

Laſtly, It melts and combines in any proportion with copper. Copper does not deſtroy its ductility; but renders it harder and more ſonorous; and the alloy is often employed in the arts.

Silver, on account of its ductility, and its being proof againſt the attacks of fire and air, is a metal ſingularly uſeful. Its luſtre recommends it for an ornament: it is laid on the ſurfaces of various bodies, and even of copper: it is wrought into ſtuffs, and adds conſiderably to their beauty. But the moſt important uſe for which it ſerves, is that of a good material out of which veſſels of all kinds may be made; and its hardneſs and ductility render it peculiarly ſuitable for this purpoſe. The ſilver wrought into plate is commonly alloyed with $\frac{1}{24}$ of copper, which improves its hardneſs and coheſion, without rendering it in any degree dangerous to the health of thoſe who uſe it; for twenty-three parts of ſilver are ſufficient to deſtroy all the noxious qualities of one part of copper.

Laſtly, Silver is coined into money, and uſed as a ſign of value for all ſorts of commodities; but in this caſe it is alloyed with $\frac{1}{12}$ of copper, and is, of conſequence only eleven penny-weights fine.

* Britiſh ſilver money is 11 penny-weights 2 grains fine. H.

CHAP.

CHAP. XXI.

Of Gold.

GOLD, the ſun of the alchemiſts, is of all known metals the moſt perfect, and the leaſt liable to alteration: its colour is a bright yellow. It is, next after platina, the moſt ponderous body in nature: In water it loſes only between a nineteenth and a twentieth part of its weight: neither its hardneſs nor its elaſticity is very conſiderable. Its ductility, of which gilding and gold wire afford ſuch amazing proofs, is ſo great, that an ounce of gold is ſufficient to gild a ſilver wire four hundred and forty-four leagues in length; and it is reducible into leaves that may be carried about before the wind. It is calculated by Lewis, that a grain of gold will cover an area more than fourteen hundred inches ſquare. It is the moſt tenacious of all metals; for a wire of gold one tenth of an inch in diameter, is ſufficient to ſupport five hundred pounds weight without breaking. Gold ſoon becomes hard and brittle under the hammer; but heat reſtores its ductility.

The colour of gold is ſubject to a good many varieties. It is ſometimes more or leſs yellow or pale, and ſometimes almoſt white: theſe differences, however, appear to be owing to ſome mixture. Gold has neither taſte nor ſmell: It cryſtallizes by cooling into ſhort quadrangular pyramids. Meſſrs Tillet and Mongez obtained it in this form.

Gold is found in nature almoſt conſtantly in a pure and virgin ſtate. It is ſometimes met with in ſmall maſſes, either ſolitary or continuous, and in a bed of quartz: At other times it is in ſmall ſpangles, among ſand, at the bottom of rivers. Laſtly, It is extracted from various ores, into the compoſition of which it enters; ſuch as galena, blende, red ſilver ore, and virgin ſilver. It is almoſt always united with a certain quantity of ſilver, or ſome other metal, forming thus a natural alloy.

There are ſeveral varieties of native gold. It exiſts in plates, in grains, in cryſtals; which are either octahædral, in priſms of four faces, or ſtriated in filaments, and in irregular maſſes. M. Sage thinks, that native gold in priſms is combined with a certain quantity of mercury, which renders it brittle.

Modern mineralogiſts reckon up various ſpecies of gold.

1. Native gold in union with ſilver, copper, iron, &c. It is found in Peru, Mexico, Hungary, Tranſylvania, &c.

2. Auriferous pyrites: It is not eaſily diſtinguiſhed from other pyrites by the eye: we diſcover the gold by diſſolving it in the nitric acid, and waſhing the reſidue. Gold is only mixed, not combined, in martial pyrites.

Some

Some arſenical pyrites, particularly thoſe of Saltzbergh in Tyrol, contain likewiſe a little gold.

3. Gold mixed with ſilver, lead, and iron mineralized by ſulphur. This auriferous ore is of a very mixed nature. According to M. Sage, it is found to contain blende, galena, ſpecular antimony, copper, ſilver, and iron; the gold melts, and drops out with the lead, when the maſs is expoſed to heat. It comes from Naggyac in Tranſylvania.

Gold ore is aſſayed in different ways, according to its nature; pulverization and waſhing are ſufficient with native gold. Gold alloyed with other metals muſt be roaſted, melted, and cupelled with lead, and parted.

It is very eaſy to conceive in what way gold is extracted from its ores, after what has been already ſaid on metallurgy in this work. Native gold needs only to be ſeparated from its gangue. For this purpoſe, it is firſt pounded; then waſhed, to ſeparate the powder of the gangue; then triturated in a mortar full of water, with 10 or 12 parts of mercury; the water being poured off after this operation, waſhes away every earthy particle from the metallic ſubſtance. When the amalgam, thus formed, appears to be ſufficiently purified from earth, it is ſtrained through goat-ſkins. Great part of the mercury paſſes through; a certain quantity remains ſtill united with the gold. The amalgam is next heated, and the mercury ſeparated from it by diſtillation; the pure gold obtained by this diſtillation is then melted, and run into bars or ingots. With reſpect to the gold that is found in combination in the ores of

other

other metals, ſuch as lead, copper, ſilver, it is extracted by eliquation, cupellation, and parting. The lead which runs down from the eliquation of copper, carries with it the ſilver and the gold. It is then cupelled, to ſeparate the lead; and the ſilver, as we ſhall hereafter mention, is ſeparated by parting.

Gold expoſed to fire becomes red-hot before it melts. When very red, it aſſumes a dazzling luſtre, and a clear green colour, like that of the aqua-marina. It does not melt till its colour change to a white red; when cooled ſlowly it cryſtallizes. It ſuffers no alteration, however long it be expoſed to fire, and however intenſe the heat; for Kunckel and Boyle found gold to have undergone no alteration by being expoſed for ſeveral months to the fire of a glaſs-houſe. This inalterability of nature is only relative, however, to the degrees of heat which we are capable of applying to it by the uſe of combuſtible matters; for it appears that a much more intenſe and active heat, ſuch as that of glaſs lenſes, deſtroys the metallic properties of gold. Homberg obſerved, on expoſing this metal to the focus of a lens of Tſchirnhauſen's, that it ſmoked, became volatile, and was even vitrified. Macquer obſerved, on expoſing gold to the focus of M. Trudaine's lens, that it melted, and exhaled a ſmoke which gilded ſilver, and could therefore be nothing but gold volatilized; that the globule of melted gold was agitated by a rapid internal motion, and became covered with a rough pellicle, ſhrivelled, and ſeemingly earthy; and that a violet-coloured vitrification was at length formed in the middle of the gold. The vitrified part was by degrees enlarged, till it formed a kind of cap of a larger curvature than the globule

of

of gold, and cloſely enchaſed in the gold in the ſame manner as the tranſparent cornea appears enchaſed in the ſclerotica of the eye The extent of the glaſs became gradually larger, and the gold was diminiſhed. The furface on which it reſts is always coloured with a purple tinge, which ſeems to be owing to the glaſs which it has abſorbed.

Time did not allow Macquer to vitrify a given quantity of gold completely. He obſerved, that it would be neceſſary to reduce the violet glaſs with combuſtible matters, in order to know whether it would afford gold, and whether it were oxide of that perfect metal. At any rate, we are of opinion, that vitrified gold may be conſidered as a true oxide of gold; and we are the rather induced to adopt this opinion, becauſe in a number of operations, which we ſhall immediately proceed to deſcribe, it invariably takes a purple colour; and ſeveral preparations of it are uſed for giving this colour to enamel and porcelain. Gold, then, like other metallic matters, may be reduced to calx; only, like ſilver, it requires a more intenſe heat, and longer time to make it combine with the baſe of vital air, than any other metallic matter: theſe circumſtances, no doubt, bear a near relation to its extraordinary denſity, and its faint tendency or averſion to combine with oxigene. It is reduced to a purpliſh oxide by electrifying it violently.

Gold ſuffers no alteration from the action of air. Its ſurface is only tarniſhed by the extraneous bodies which are continually floating in the atmoſphere. Water does not alter it in any way; from the experiments of Garaye, however, it appears that this ſubſtance

ſtance gradually divides it in the ſame manner as iron.

Gold in its metallic ſtate does not combine with earths or ſalino-terrene ſubſtances. Its oxide enters into the compoſition of glaſſes, and communicates to them a violet or purple colour.

Gold is not liable to ſuffer from the attacks of the ſulphuric acid, however highly concentrated, and even aſſiſted by heat.

The nitric acid diſſolves a few particles of this metal; but it is perhaps rather mechanically than by true combination. Brandt was among the firſt chemiſts who aſſerted gold to be ſoluble in the nitric acid: the fact has been ſince confirmed by the experiments of Scheffer and Bergman. But we muſt obſerve, that, according to experiments made by the whole chemiſts of the Academy of Paris, the nitric acid produces this effect only in certain circumſtances. M. Deyeux, member of the College of Pharmacy, has remarked, that the acid of nitre diſſolves gold, only when it is ruddy, and contains nitrous gas. According to him, the acid is not pure in this ſtate: he calls it *acid impregnated with gas*, and deſcribes it as a kind of *aqua-regia*. We have elſewhere ſhown in what conſiſts the difference between the nitrous and the nitric acid.

The muriatic acid alone, and in a ſtate of purity, acts not upon gold in any ſenſible degree. Scheele and Bergman have diſcovered, that the oxigenated muriatic acid diſſolves gold in the ſame way as *aqua-regia*; and forms alſo with the metal the ſame ſalt which it forms with the mixed acid uſually employed to diſſolve it. It is the exceſs of oxigene united with the muriatic acid which

cauſes

cauſes the ſolution to take place: it it accompanied with no ſenſible effervescence, like the other ſolutions of metals, by the oxigenated muriatic acid.

Aqua-regia has been conſidered as the true ſolvent of gold. It diſſolves it, however, no better than the oxigenated muriatic acid. As it would be improper to repeat here what we have elſewhere ſaid concerning the nature and properties of this mixed acid, and the varieties to which it is liable, according as the proportions of the two acids by the combination of which it is formed vary, we ſhall ſpeak only of the manner in which it acts upon gold. As ſoon as the nitro-muriatic acid comes into contact with this metal, attacks it with an effervescence; which, the more concentrated the acid, the hotter the temperature, and the more divided the integrant parts of the gold, is ſo much the more lively. This operation may be more ſpeedily effected by a moderate heat; at leaſt a moderate heat is favourable in the beginning of the proceſs. Bubbles then riſe in conſtant ſucceſſion, till a part of the metal be diſſolved. This action by degrees ceaſes; ſtirring or heat is requiſite to make it continue. Nitrous gas is diſengaged while the ſolution is taking place. The nitro-muriatic acid, when ſaturated with the full quantity of gold which it is capable of diſſolving, takes a yellow colour of a lighter or a deeper ſhade. It is conſiderably cauſtic; it tinges animal matters with a deep purple colour, and corrodes them: When evaporated with proper management, it affords cryſtals of a beautiful golden colour, reſembling topazes, and appearing to be truncated octahædrons, and ſometimes tetrahædral priſms. It is difficult enough to obtain this cryſtallization. M. Monnet thinks it

owing to a neutral ſalt, ready formed in the nitro-muriatic acid; and aſſerts, that in order to obtain it, the *aqua-regia* made uſe of ſhould be compoſed of nitric acid with ammoniacal muriate, or muriate of ſoda. A mixed acid prepared in this manner cannot but contain nitrate of of ſoda, or ammoniacal nitrate. It is either the one or the other of theſe neutral ſalts, according to the chemiſt whoſe opinion we are mentioning, which occaſions the cryſtallization of gold. It appears, however, that a ſolution of gold in nitro-muriatic acid, made up of pure acids, is capable of affording cryſtals; and Bergman conſiders the ſalt as muriate of gold. Theſe cryſtals, when heated, melt and take a red colour. This ſalt powerfully attracts the moiſture of the atmoſphere. A ſolution of gold gives, by diſtillation, a beautiful red colour, whichis nothing but muriatic acid impregnated with a little gold. The alchemiſts who have laboured ſo much upon gold, called this liquor *red lion.* A few golden cryſtals are likewiſe ſublimated, the colour of which is a reddiſh yellow. Moſt part of the metal remains at the bottom of the crucible; and fuſion purifies it, ſo that it again diſplays all its properties.

The ſolution of gold may be decompoſed by a great many intermedia. Lime and magneſia precipitate the gold in the form of a yellowiſh powder. Fixed alkalis afford the ſame phænomenon. But it is to be obſerved, that the precipitate is but very ſlowly formed; and the ſolution takes a reddiſh colour, if more alkali be employed than what is abſolutely requiſite; for the exceſs of alkali again diſſolves the precipitated gold. The precipitate of gold may be reduced by heat in cloſe veſſels; it is an oxide which readily gives out its oxigene in the ſtate

of

of vital air. This oxide, however, is fuſible with vitreous matters, and communicates to them a purple colour; for enamels and porcelain are coloured with a precipitate of gold, formed by mixing a ſolution of gold with liquor of flints.

Gold precipitated by fixed alkali exhibits likewiſe another property, very different from thoſe which gold poſſeſſes in its metallic ſtate: it is ſoluble in pure ſulphuric, nitric, or muriatic acid. All of theſe acids, when heated on the yellowiſh precipitate of gold, readily diſſolve it; but they do not take up ſo much of it as to afford cryſtals. When theſe ſolutions are evaporated, the gold is very quickly precipitated; the ſame thing happens by reſt. M. Monnet has obſerved a fact concerning the precipitation of gold by nut-gall *, which muſt not be forgotten; it is, that the precipitate which is reddiſh, diſſolves very well in the nitric acid, and communicates to it a beautiful blue colour.

* As we have taken notice only of the precipitation of iron by nut-gall, we ſhall give a ſhort account of the phænomena which this aſtringent ſubſtance exhibit with moſt other metallic ſubſtances.

Nut-gall, with the ſolution of cobalt, gives a clear blue precipitate; with the ſolution of zinc, an aſh-green precipitate; with the ſolution of copper, a green precipitate, which becomes grey and reddiſh; with a ſolution of ſilver, it gives firſt reddiſh ſtriæ, which take afterwards the colour of burnt coffee; with the ſolution of gold, a purple precipitate. Theſe facts have been obſerved and deſcribed by M. Monnet; and he has obſerved farther, that theſe precipitates are ſoluble in acids; and that alkalis combine with the latter ſolutions without producing precipitates.

The academicians of Dijon have added to theſe facts the following new obſervations. 1. The ſolution of arſenic is not altered by nut-gall;

Ammoniac precipitates the ſolution of gold in much greater abundance. This precipitate is of a brown yellow, and ſometimes of an orange colour; when expoſed even to a moderate heat, it detonizes with a conſiderable noiſe; it has been called *fulminating gold*. Ammoniac is indiſpenſibly neceſſary to its production. It may be formed, either by precipitating, by fixed alkali, a ſolution of gold made in nitro-muriatic acid, compoſed with ammoniacal muriate; or rather, by precipitating, by ammoniac, a ſolution of gold made in aqua-regia, compoſed of pure nitric and muriatic acid. The fulminating gold thus obtained is always one fourth more in quantity than the gold diſſolved in the *aqua-regia*. There are ſome precautions neceſſary to be taken in order to eſcape ſuffering from the terrible effects of fulminating gold. In the firſt place, it muſt be dried cautiouſly, and in the open air, at a diſtance from any fire; for a very moderate degree of heat is ſufficient to make it fulminate. As friction alone would be enough to make it give an explo-

ſion

gall; with the ſolution of biſmuth, nut-gall produces a greeniſh precipitate; with the ſolution of nickel, a white precipitate; with the ſolution of antimony, a bluiſh grey precipitate; with lead, a ſlaty ſediment, the ſurface of which is covered with pellicles of a mixed green and red colour; laſtly, the ſolution of tin takes a dirty grey colour, by mixture with nut-gall, and gives a copious precipitate, ſomewhat of a mucilaginous nature. Under the article of the Gallic Acid, or acid of galls, in the vegetable kingdoms, ſeveral of theſe facts will again draw our attention.

It may be proper to obſerve here, that the experiments of M. Monnet, and of the academicians of Dijon, were made with a decoction of the nut-gall: whilſt thoſe which will be taken notice of in the vegetable kingdom, refer to the action of the *gallic acid* on metallic ſolutions, which accounts for the difference of the reſults in the two caſes. F.

ſion, the veſſels into which it is put muſt be ſtopped only with cork. Some unlucky accidents have ſhewn, that cryſtal ſtoppers, by their friction on the necks of the bottles, may cauſe ſuch particles of the powder as adhere to that part of the bottle to fulminate; and by communication with the reſt of the powder, to produce the moſt dangerous effects. A terrible accident happened in M. Baumé's laboratory, of which he has given an account in his *Theory and Practice of Chemiſtry.*

Chemiſts have entertained various opinions concerning the cauſe of the detonation of fulminating gold. Baumé gave it as his opinion, that in this inſtance there was formed *nitrous ſulphure*, which he conſidered as the fulminating principle of this compound. But Bergman has proved his theory inadmiſſible, having formed fulminating gold without nitric acid, by diſſolving a precipitate of gold in ſulphuric acid, and precipitating it anew by ammonaic. Neither can the fulmination of this gold be owing to ammoniacal nitrate; for after being copiouſly waſhed in water, which would certainly carry off any portion of that ſalt which it might contain, it ſtill retained its fulminating powers. On examining attentively what paſſes in the detonation of fulminating gold, it is obſerved to take fire at the very inſtant when it ſhivers into pieces. When it is expoſed to the moderate heat of warm aſhes, it gives out, before the exploſion, ſparks like thoſe of electric fire; when expoſed to the ſpark produced by the Leyden bottle, it detonizes; a ſimple ſpark without motion does not kindle it; laſtly, after fulminating, it leaves the gold in a metallic ſtate. It appears, therefore, that the fulmination of this gold is owing to ſome combuſtible matter contained in the com-

pound. And as ammoniacal gas is neceſſary to the production of fulminating gold, it is at preſent agreed, that the exploſion ought to be attributed to that ſubſtance. This theory is founded on the following facts.

1. M. Berthollet has obtained ammoniac gas by applying a gentle heat to copper tubes, containing fulminating gold, and communicating at one end by means of a ſyphon, with a pneumato-chemical apparatus with mercury. The gold was now no longer fulminating, but was reduced to oxide.

2. Bergman, having expoſed fulminating gold to a degree of heat not ſufficient to make it fulminate, gradually deprived it of its fulminating powers, by volatilizing the ammoniac gas which it contained.

3. When a few grains of fulminating gold are made to detonize in copper tubes, communicating with a pneumato-chemical apparatus with mercury, gas azote, and a few drops of water, are obtained as products, and the gold is found to be reduced. M. Berthollet, to whom we owe this fact, thinks that in this inſtance ammoniac is decompoſed; that the hydrogene which it contains, uniting with the oxigene of the oxide of gold, reduces it by forming water; and that the gas azote, being thus ſet at liberty, is conſequently diſengaged: the fulmination appears therefore to be owing to the combuſtion of hydrogene, and the ſudden diſengagement of gas azote.

4. The concentrated ſulphuric acid, melted ſulphur, fat oils, and æther, deprives this precipitate of its fulminating powers, by detaching its ammoniac.

A ſingular property of fulminating gold, which ſhows with

with what force it acts, is its making a mark or hole on any metal plate, ſuch as a plate of lead, tin, and even ſilver, on which it is fulminated. But it does not appear to be liable to take fire in a very cloſe veſſel; for Lewis relates, that it produced no exploſion when incloſed in an iron ball, and expoſed to an intenſe heat. The cauſe of this phænomenon ſeems to be, that there is not then room for the diſengagement of the gas azote. Bergman, who did not well know the nature of the gas diſengaged during the fulmination of this precipitate, and conſidered it as pure air impregnated with a little ammoniac, has given a ſimilar explanation of the experiments made on this matter before the Royal Society of London. The reader may conſult his valuable Diſſertation *de calce auri fulminante*, in his *Opuſcula*. M. Berthollet diſcovered that oxide of ſilver, precipitated from nitric acid by lime, and digeſted with ammoniac till it take a black colour, acquires the property of detonizing, not only by a heat a very little ſuperior to that of boiling water, but likewiſe by a ſlight friction againſt any body. Here, then, we have fulminating ſilver of a ſtill more ſingular nature than the gold ſo called; which, however, owes its fulminating properties to the ſame cauſe. The ammoniac decanted from above this oxide, depoſites, by ſlow evaporation, ſmall, bright, lamellated cryſtals, poſſeſſing the property of fulminating, even under water, by ſimple friction.

The ſolution of gold is precipitated by alkaline ſulphures. When the fixed alkali combines with the acid, the ſulphur that is precipitated unites with the gold; but this combination is not very permanent; it is enough to heat the gold, and the ſulphur is then volati-

lized, and the perfect metal left in a ſtate of purity. It is proper to obſerve, that the gold precipitated from a ſolution by an intermedium, is perfectly pure, even more ſo than gold obtained by parting, being ſeparated from the ſilver which it would otherwiſe have contained, in conſequence of that metal being precipitated in the form of a muriate, even during the ſolution of the gold, as we have above obſerved.

Gold has not a greater affinity than all the other metals with the nitro-muriatic acid; on the contrary, almoſt any other metallic ſubſtance is capable of ſeparating it from its ſolvent. Biſmuth, zinc, and mercury, precipitate gold. A plate of tin immerſed into a ſolution of gold ſeparates this perfect metal into a powder of a deep violet colour, which is called purple precipitate of *Caſſius*. This precipitate, which is uſed for painting on enamels and porcelain, is prepared by diluting a ſolution of tin in nitro-muriatic acid, with a large quantity of diſtilled water, and pouring upon it a few drops of a ſolution of gold. When the ſolutions are pretty much concentrated, there is inſtantaneouſly formed a precipitate of a red crimſon colour, which in a very few days changes to purple: the precipitate is light, and ſomewhat mucilaginous; the liquor is filtrated, and the precipitate waſhed and dried. This matter is a compound of oxide of tin and oxide of gold; the preparation of it is one of the moſt ſingular operations of chemiſtry, on account of the variety and the inconſtancy of the phænomena which attend it. Sometimes it affords a beautiful red precipitate; ſometimes its colour is only a deep violet: and what is moſt ſurpriſing, it happens pretty often, that the mixture of theſe two ſo-

ſolutions

lutions produces no precipitate. Macquer, to whom theſe varieties were very well known, obſerves, that they depend almoſt always on the ſtate of the ſolution of tin employed. If the ſolution have been haſtily effected, the metal is too much oxidated, and there is too little of it contained in the ſolution for the acid of the ſolution of gold to act upon it; for he attributes the formation of the purple precipitate of *Caſſius* to the action of that acid upon the tin. According to him, to ſucceed in this operation, the ſolution employed muſt have been very ſlowly made, ſo as to contain as much tin as poſſible, without the metal being too much oxidated. He accordingly gives the following direction, for preparing the purple precipitate. Diſſolve the tin, one part after another, in an acid conſiſting of two parts of nitric acid, and one of muriatic acid, with an equal weight of diſtilled water; on the other hand, diſſolve with the help of heat, a quantity of very pure gold in another mixed acid, conſiſting of three parts of nitric and one of muriatic acid. Dilute this ſolution of tin in an hundred parts of diſtilled water; divide it into two parts; add to one of them a new quantity of water, and try both of them with a drop of the ſolution of gold; obſerve then which of them affords the moſt beautiful red, and treat the other in the ſame manner with it; then pour in the ſolution of gold till it ceaſe to afford a precipitate.

Lead, iron, copper, and ſilver, poſſeſs likewiſe the property of ſeparating gold from its ſolution. Lead and ſilver ſeparate it into a dirty dark purple precipitate. By copper and iron it is precipitated with its metallic luſtre. The nitric ſolution of ſilver, and that of ſulphate

of iron, produce likewiſe a red or brown precipitate in a ſolution of gold.

Neutral ſalts act not in a very conſpicuous manner on gold. Only it is obſerved, that borax melted with this metal alters its colour, and gives it a ſtrange paleneſs: but nitre and muriate of ſoda reſtore it to its former ſtate. A ſolution of borax poured into a ſolution of gold, forms a precipitate of boracic acid, impregnated with gold.

Sulphur is incapable of combining with gold; and this mineral is therefore employed to ſeparate ſuch other metals as happen to be united with gold, eſpecially ſilver. The alloy is melted in a crucible; when it is fully melted, flowers of ſulphur, or ſulphur in powder, are caſt on its ſurface: the ſulphur melting, and combining with the ſilver, thus forms a blackiſh ſcoria, which ſwims above the gold. It is to be obſerved, that the two metals are never entirely ſeparated by this operation, which is called *dry parting;* and that it is applied only to lumps of ſilver containing too little gold to be worth the expence of parting by aqua-fortis.

Alkaline ſulphure diſſolves gold entirely. Stahl even thinks, that it was by ſuch a proceſs that Moſes made the Iſraelites drink the golden calf that they had worſhipped. In making this combination, a mixture, conſiſting of equal parts of ſulphur and potaſh, is haſtily melted with a quantity of gold leaf, amounting to an eighth part of the weight of the whole maſs. This melted matter is poured upon a ſurface of porphyry, pulverized, and diluted with hot diſtilled water; it now forms a yellowiſh green ſolution, containing an auri-

ferous

ferous ſulphure of potaſh. This metal may be precipitated by means of acids, and ſeparated from the ſulphur precipitated together with it, by heating it in open veſſels.

Gold combines with moſt metallic matters; and in its combinations with them exhibits a number of important phænomena.

It unites with arſenic. This metal renders its contexture brittle, and its colour very pale. It is ſcarce poſſible to ſeparate the arſenic entirely from this mixture: the gold ſeems to render it more fixed in its nature.

We are unacquainted with any alloy of gold with cobalt. It combines with biſmuth, which renders it white and brittle; in the ſame manner with nickel and antimony. As theſe metals are all eaſily oxidated, and moſtly fuſible, they are eaſily ſeparated from gold by the joint action of fire and air.

Sulphure of antimony has been loudly praiſed by the alchemiſts as a purifier of gold. When this metal is alloyed with any extraneous metallic ſubſtance, ſuch as copper, iron, or ſilver, on melting with it ſulphure of antimony, the ſulphure unites with theſe ſubſtances, and ſeparates them from the gold, which is found by itſelf at the bottom of the veſſel. This gold, however, is alloyed with antimony; it is purified by heating it to a white red. The antimony is then volatilized; a very intenſe fire, however, is requiſite to ſeparate it entirely; and it is obſerved, the antimony carries with it ſome part of the gold. This proceſs, which was ſo famous among the alchemiſts, is in no way preferable to

that in which ſulphur alone is employed for the ſame purpoſe.

Gold eaſily unites with zinc: the mixed metal reſulting from this union is the whiter, and the more brittle, in proportion as the quantity in which the zinc enters into the mixture is greater. An alloy conſiſting of equal parts of theſe two ſubſtances is of a very fine grain; and takes ſo beautiful a poliſh, that it has been recommended by Hellot as proper for making mirrors to teleſcopes, not liable to loſe their luſtre. When the zinc is ſeparated from the gold by calcination, the oxide of the zinc is reddiſh, and carries with it a little gold, as mentioned by Stahl.

Gold has a greater affinity than any other metallic ſubſtance with mercury, and decompoſes amalgams of any other metal with mercury. It unites with mercury in all proportions, forming with it an amalgam; which the greater the proportion of the gold, is ſo much the more ſolid and the higher coloured. This amalgam is liquified by heat, and cryſtallized by cooling, like almoſt all the other compounds of this kind. We know not well what regular form it takes. M. Sage ſays, that its cryſtals are like feathered ſilver; and that, when viewed through the magnifier, they appear to be quadrangular priſms. He aſſerts likewiſe, that the mercury becomes fixed in this combination. This amalgam is uſed for gilding in *water-gold.*

Although gold cannot be oxidated by the joint action of the air and the fires of our furnaces, it ſuffers that change, however, when heated with mercury. Mercury, with a forty-eighth part of gold, heated in a flat-bottomed matraſs with a very narrow neck, on a ſand-bath,

bath, in the ſame way as oxide of mercury is heated in preparing *precipitate per ſe*, is itſelf oxidated, and cauſes the ſame phænomenon to take place on the gold. The mixture is changed into a dark red powder; and this double oxide is obtained even much ſooner, according to M. Baumé, than oxide of mercury heated by itſelf.

Here, then, we have a metal which, though exceedingly difficult to oxidate by itſelf, haſtens and facilitates the oxidation of another metallic matter, which does not readily ſuffer ſuch a change by itſelf.

Gold enters very readily into union with tin and lead: either of theſe metals totally deſtroys its ductility. With iron it forms a very hard alloy, of which, inſtruments for cutting may be formed much ſuperior to thoſe which are made of pure ſteel. This mixed metal is grey, and ſubject to the attraction of the magnet. Lewis propoſes the uſe of gold to ſolder ſmall pieces of ſteel neatly, and in a very ſolid manner.

Gold combines with copper, which renders it red, hard, and more fuſible. This alloy is fixed at different proportions for pieces of money, veſſels, and oys.

Laſtly, Gold combines with ſilver, which changes its colour, and renders it very pale. A certain difficulty, however, attends this mixture, on account of the different gravities of the two metals; as has been obſerved by Homberg, who ſaw them ſeparate when melted together. The alloy of ſilver with gold forms the jeweller's *green gold*.

As the uſe of gold is very extenſive, and as men have agreed to uſe gold and ſilver as common ſigns to repreſent

repreſent the value of all the other productions of nature and art, it is of great importance to be able to diſtinguiſh the degree of the purity of any piece of this metal, in order to the prevention of fraud, and that all the gold which circulates in commerce may be nearly of the ſame intrinſic value. Juſt and ſevere laws have preſcribed the particular alloy of gold to be employed in making utenſils, and have pointed out the proportions requiſite to give it a due degree of hardneſs and inflexibility for that purpoſe. Chemiſtry affords means for diſtinguiſhing with what quantity of any other metal, gold may be at any time alloyed. The operation by which this is accompliſhed is called *the aſſay of gold.* Twenty-four grains of the gold to be aſſayed are cupelled for this purpoſe, with forty-eight grains of ſilver, and four drachms of pure lead. The lead as it vitrifies carries off with it the imperfect metals, ſuch as copper, &c. The gold remains, after the cupellation, in combination with the ſilver. Theſe two metals again are ſeparated by an operation which bears the name of *parting.* To part an alloy of gold and ſilver, is to ſeparate the two metals by a ſolvent, which may act upon the ſilver without affecting the gold. Aquafortis is commonly uſed. The deſign in adding the ſilver to the gold was, that all the ſilver in the gold might be completely diſſolved by the nitric acid; for experience has ſhown, that gold muſt contain at leaſt twice its weight of ſilver, before the nitric acid can act ſo as to diſſolve the ſilver totally. As three parts of ſilver are often added to the gold, this operation is called *quartation*, as the gold compoſes in fact but one-fourth part of the

mixture.

mixture. The following is the way of performing this proceſs of *parting*.

The cupelled alloy of gold and ſilver is firſt hammered flat, care being taken to heat and turn it frequently, that it may not ſplit, nor ſeparate into ſmall parts, in conſequence of becoming hard and brittle under the hammer: it is then rolled up in feathers in a ſpiral form; in this form it is put into a ſmall matraſs, and ſix drams of precipitated aquafortis, unmixed with muriatic acid, but diluted with half that quantity of water, are poured upon it. The veſſel is expoſed to a moderate heat, till the mixture begin to effervesce. The ſilver is ſoon after diſſolved, and the metallic coil takes a brown colour. When the acid ceaſes to act, it is then decanted off; and a new quantity is poured upon the metal, and boiled on it till the ſilver be entirely diſſolved. This ſecond operation is called a *repetition*. The acid is then decanted off, and the ſpiral piece of metal, now become very thin, and perforated with a great many holes, is waſhed; it is poured with water into a crucible; the water decanted off, the crucible made red-hot, and the gold now diſplays all its properties. It is next weighed, and its weight ſhows the degree of the fineneſs of the gold. In order to know exactly what quantity of other metals gold contains, any maſs of gold whatever is ſuppoſed to conſiſt of twenty-four parts, called *carats;* and to attain ſtill greater accuracy, each carrat is divided into two and thirty parts, called *thirty-ſeconds of a carat*. If the gold thus aſſayed have loſt one grain in twenty-four, the maſs to which it belonged is conſidered as gold of twenty-three carats; if a grain and an half, it is then gold of twenty

twenty carats, ſixteen thirty-ſeconds, and ſo on. The weight made uſe of in aſſaying gold is called *ſole weight*, and conſiſts commonly of twenty-four grains; it is divided into twenty-four carats, which are again ſubdivided into thirty-two parts. There is alſo another weight uſed on the ſame occaſion, weighing twelve grains, but divided into twenty-four carats, and the carat again into thirty-two parts.

There are two important obſervations to be made on this operation of parting.

1. It has been thought by ſome chemiſts, that the nitric acid diſſolves a little gold with the ſilver. M. Baumé has obſerved (*pages* 117 and 118 *of the third volume of his Chemiſtry*), that ſilver extracted from gold by parting, retains in it a diſcernible quantity of the gold. From two pounds of fine grain-ſilver, which that chemiſt employed in making *Lapis Infernus*, he ſays, that he uſually ſeparated about half a dram of gold in black powder. However, when the operation of parting is effected with an acid not too much concentrated, and the ſolution not carried too far, the gold then remains pure and uninjured, and there is none of it diſſolved with the ſilver. The chemical claſs of the Academy have been employed by adminiſtration, to examine whether the nitric acid diſſolves gold in the proceſs of parting. From a long train of experiments made for this purpoſe, they have concluded, that, "in "the proceſs of parting, performed according to the "received rules and mode of operation, the gold can "never ſuffer the ſmalleſt loſs; and that the operation "is to be regarded as carried to the utmoſt perfection "of which it is capable." This deciſion, which we have

have extracted from the Report publiſhed by the Academy on the occaſion, cannot but give full ſatisfaction to the public, and re-eſtabliſh their confidence in the proceſs in queſtion.

2. Many gentlemen ſkilled in aſſaying, and among others Schindler and Schlutter have been of opinion, that the gold after parting ſtill retains a little ſilver. That portion they call *ſurcharge*, or *inter-halt*. Meſſrs Hellot, Macquer, and Tillet, being employed to examine the operation of the money-aſſayers, proved this aſſertion to be groundleſs. M. Sage, however, in his work entitled, *The Art of Aſſaying Gold and Silver, page* 64, aſſerts, that the ſpiral piece of gold always retains a little ſilver, which may be proved to exiſt in it by diſſolving the ſuſpected gold in twelve parts of nitro-muriatic acid: the ſolution being cooled, depoſites in a certain ſpace of time, often twelve hours after it is made, a little muriate of ſilver, in the form of a white powder.

Gold is applied to a great many uſes. Its ſcarcity, and the high value ſet upon it, hinder it from being uſed for veſſels and other utenſils, like ſilver; but as its colour and luſtre are very pleaſing to the ſight, it is therefore applied as a gilding or plating to the ſurfaces of many bodies, which it at the ſame time defends from the impreſſion of the air.

The modes of gilding are very various. Gold-leaf is ſometimes glued on pieces of wood. Powder of gold is prepared by braying clippings of gold-leaf with honey, waſhing them with water, and drying the particles of gold that are precipitated. *Shell-gold* is an oxide of gold diluted in a mucilaginous liquor, prepared by the ſolution of a gum in water. The name of *gold in rags*

is given to the following preparation: Pieces of linen ſteeped in a ſolution of gold, dried and burnt. In making uſe of them, a wet cork is dipped in theſe aſhes, and rubbed upon ſilver; on which the gold, being in a ſtate of extreme diviſion, readily fixes. We have already ſpoken of gilding with water-gold. To make uſe of it, the piece of copper to be gilded muſt firſt be well ſcoured with ſand and a weak aquafortis, which the workmen call *ſecond water;* it is then immerſed into a very weak ſolution of mercury: the mercury being precipitated, cauſes the amalgam of gold, which is applied to the piece, after waſhing it with water, to carry away acid, to adhere. When the amalgam is uniformly extended over the copper, the piece is then heated on the coals, to volatilize the mercury; the operation is concluded by rubbing upon the gold gilder's wax, which is compoſed of *red bole*, *verdigris*, *alum*, or *martial vitriol*, with yellow wax, and heating the gilt piece for the laſt time to burn the wax.

The other uſes of gold for toys and laces are ſufficiently known, ſo that it is unneceſſary for us to inſiſt on them here. With reſpect to the medicinal virtues which have been aſcribed to it, the beſt phyſicians at preſent agree in denying their exiſtence, and think that any effects produced by the ſeveral potable preparations of gold muſt have been owing not to the gold, but to other matters mixed with it in the ſolution.

CHAP.

A valuable gold mine has been lately diſcovered in Ireland. Gold is ſtill found in ſpangles, in the brook of Glengonar, in Crawfurd-Muir, in Scotland. Gold exiſts naturally in all vegetables. It is highly probable, notwithſtanding the experiments of the French Academy, that nitric acid, however pure, always diſſolves a certain proportion of gold ſubjected to its action, in the ordinary proceſs of parting. H.

CHAP. XXII.

Of Platina.

PLATINA, which has been known as a peculiar metal only during the laſt forty years, has not yet been found any where but in the gold-mines of America, particularly in that of Santa Fé, near Carthagena, and in the bailiwick of Choco in Peru. The Spaniards have given it this name from *plata*, which in their language ſignifies ſilver; comparing it with this metal, of which it has in fact the colour: But the name of *white gold* appears to agree much better with its nature than that of *ſmall ſilver*; for in its properties it reſembles gold much more than ſilver.

Before the period which we have mentioned, there were ſome toys of platina. But as this metal cannot be melted and wrought by itſelf, it is probable that the ſnuff-boxes, heads of canes, and other utenſils of this kind, ſold under the name of *platina*, were mixtures of that metal, with ſome other metallic ſubſtances; which, as we ſhall ſee, are neceſſary to render it fuſible.

The platina in cabinets is in the form of ſmall grains or ſpangles of a livid white, inclining at once to the colour both of iron and of ſilver. Theſe grains are mixed with various extraneous ſubſtances; they are found to contain ſpangles of gold, blackiſh ferruginous ſand; grains which, when viewed with the magnifier, appear to be ſcorified like *machefer*, and ſome particles of mercury. The mercury is ſeparated from this mixture by heating it; waſhing carries off the ſand and the grains of iron; the iron may likewiſe be ſeparated by the magnet: after this there remains nothing but gold and platina, which may be eaſily ſeparated by picking, as Margraff has done. The grains of platina, when examined with the microſcope, appear, ſome of them triangular, others round and flat, like ſmall cakes. When hammered upon ſteel, moſt of them are found to be malleable and ductile: ſome of them break into pieces on ſuch an occaſion. Theſe, when narrowly examined, are found to be hollow, and to contain within, iron and a white powder. It is, doubtleſs, on the principle of their containing ferruginous particles, that the property which ſome grains of platina poſſeſs of being ſubject to the attraction of the loadſtone, however purified from ferruginous ſand, is to be accounted for.

This metal is very nearly as hard as iron. The ſpecific gravity of platina, mixed with the ſeveral extraneous matters which we have mentioned, is nearly equal to that of gold: in water it loſes from a ſixteenth to an eighteenth part of its weight. Buffon and M. Tillet, on comparing, by weight, equal bulks of platina and gold reduced to grains like thoſe of platina, found the ſpecific gravity of platina to be one twelfth leſs than

that of gold. It has been aſcertained by later experiments, that platina, after being purified by a long fuſion, is ſuperior in ſpecific gravity to gold.

Probably platina is not found in the mines in the ſame form in which it is brought to us; it poſſibly owes its granulated form to the waters which carry it down from the hills into the plains. It is ſometimes found in pretty conſiderable pieces: the Society of Biſcay are in poſſeſſion of a piece as large as a pigeon's egg. Platina, being found in places adjacent to gold-mines, always contains a certain quantity of that metal. As to the mercury mixed with it, this metal has been employed in extracting the gold.

Though toys made of platina have long been ſold, yet the peculiar nature of the metal was unknown. Even the workers of mines had not paid any particular attention to it; but neglected a matter which had no very beautiful aſpect, and was beſides very difficult to work. For our firſt knowledge of platina, we are indebted to a Spaniſh mathematician, Don Antonio de Ulloa, who accompanied the French academicians that were ſent on the famous journey to Peru, to aſcertain the figure of the earth. In the account of his journey, publiſhed at Madrid in the year 1748, he makes mention of this metal. Charles Wood, an Engliſh metallurgiſt, had brought ſome of it from Jamaica in the year 1741. He then examined it, and gave an account of his experiments in the Philoſophical Tranſactions for the years 1749 and 1750. At that period, the greateſt chemiſts in Europe engaged eagerly in the examination of this new metal, the ſingular properties of which promiſed to render it ſo uſeful. Scheffer, a

Swediſh chemiſt, publiſhed an account of his experiments on platina, in the Memoirs of the Academy of Stockholm for 1752. Lewis, an Engliſh chemiſt, made a ſeries of experiments, almoſt complete, upon this metal, which may be found in the Philoſophical Tranſactions for the year 1754. Margraff has given a detail of his experiments on this new metal in the Memoirs of the Academy of Berlin for 1757. Moſt of theſe ſeparate memoirs have been collected into one body by M. Morin, in a work entitled, *Platina, white gold, or the eighth metal, Paris* 1758. About the ſame time, Meſſrs Macquer and Baumé jointly made many important experiments on platina; an account of which has been publiſhed in the Memoirs of the Academy for the year 1758. Buffon, in the firſt volume of the Supplement to his Natural Hiſtory, gives an account of a train of experiments on platina, made by himſelf, M. de Morveau, and the Count de Milly. The Baron de Sickengen likewiſe engaged in a ſeries of reſearches on the metal of which we are now ſpeaking; but his work has not yet been publiſhed in French. Macquer gives an extract from it in his Chemical Dictionary. M. de Lille has preſented to the Academy a paper on platina. The ſcarcity of the metal, and the difficulties attending the treatment of it, have retarded our progreſs towards a complete knowledge of its properties: but of late the inquiries concerning it have been reſumed with new ardour. Bergman, M. Achard, and M. de Morveau, have examined this metal in reſpect to ſeveral of its properties, which were before but little known.

Platina, when purified and ſeparated by waſhing, picking, and muriatic acid, from the extraneous bodies which it contains, ſuffers no alteration of nature, only

conglomerating

conglomerating a little more by expoſure to the moſt intenſe heat. All the chemiſts who have examined the metal agree in this. Meſſrs Macquer and Baumé kept platina for a number of days expoſed to an unremitting fire in a glaſs-houſe, without producing any other alteration on its grains, but that of making them adhere ſlightly together; and they were even ſo feebly agglutinated as to be ſeparable barely by touching them. In theſe experiments, they obſerved, that platina acquired a luſtre when heated to a red white; that when very long expoſed to heat, it took a dirty grey colour; and, laſtly, that, as Margraff had aſſerted, it conſtantly increaſed in weight; which could only happen in conſequence of its being reduced in part to oxide; a change which it appears liable to ſuffer from the action of fire. Thoſe chemiſts expoſed platina to the focus of a burning glaſs: it firſt ſmoked, and gave out very red and lively ſparks; the portions of metal expoſed to the centre of the focus were next melted in about the ſpace of a minute: the melted parts were of a ſparkling white colour, and in the form of a button; they were diviſible into plates with a knife. One of theſe maſſes of melted platina being ſtruck upon ſteel, became flat, and was reduced into a plate without ſplitting or cracking: it became hard and brittle under the hammer. This fine experiment ſhows platina to be fuſible by extreme violence of fire; to be malleable like ſilver and gold; and to be liable to very little alteration from the action of fire: for in all of theſe experiments, moſt of which were performed in the open air, the platina exhibited no marks of being oxidated. M. de Morveau likewiſe effected the fuſion of platina by heating it in the wind-

furnace deſcribed by Macquer, with his reductive flux, conſiſting of eight parts of pounded glaſs, one part of calcined borax, and half a part of charcoal in powder. At preſent it is very eaſily melted in ſmall portions, without the addition of any other ſubſtance, by heating it on a burning coal with a ſtream of vital air: but the globules, thus melted, are ſo very ſmall, that they can anſwer no purpoſe.

Platina ſuffers no alteration from expoſure to the air: we know not, however, what might happen, if it were kept for a long while red-hot, in contact with air: perhaps it would be oxidated, as Juncker aſſerts that ſilver and gold are, when heated in this way.

This metal ſuffers no alteration from water, earthy matters, ſalino-terrene ſubſtances, or alkalis.

Neither the ſulphuric acid, however highly concentrated, the nitric, nor the muriatic acid, however ſtrong and fuming, act at all on platina, even though aſſiſted by ebullition. Diſtillation, a method which chemiſts have always found very effectual in promoting the action of acids on metallic matters, does not effect any ſolution or alteration of theſe mixtures; only, the ſulphuric acid has been obſerved by Meſſrs Lewis and Baumé, to tarniſh the colour of grains of platina. The nitric acid again improves their luſtre. Margraff ſays, that he obtained, by diſtilling this acid with platina, towards the end of the operation, a little arſenic; which phænomenon has not been obſerved by any other chemiſt. The muriatic acid produces no change on platina. Margraff likewiſe obtained, by diſtilling this acid on the metal, a white ſublimate, which appeared to him to be arſenic, and a reddiſh ſublimate, the quantity

tity of which was ſo ſmall, that he could not examine its properties. All of theſe ſubſtances are evidently extraneous to platina. This metal, therefore, reſembles gold, in being but little ſubject to be affected by the action of ſimple acids; but ſtill more in being ſoluble in the oxigenated muriatic, and in the nitro-muriatic acid.

The firſt of theſe acids diſſolves platina with eaſe, and without requiring the aſſiſtance of any conſiderable heat: Fifteen or twenty degrees of heat in the atmoſphere are ſufficient to promote this ſolution: it takes place without any ſenſible efferveſcence; and, in other reſpects, perfectly reſembles the following ſolution.

The nitro-muriatic acid, which is the moſt powerful ſolvent of platina, is that conſiſting of equal parts of nitric and muriatic acid. To effect this ſolution, which is generally more difficult than that of gold, an ounce of platina muſt be put into a retort, and a pound of nitro-muriatic acid, conſiſting of the above-mentioned proportions, mixed with it: the retort muſt then be put on a ſand-bath, and a receiver fitted to it. As ſoon as the acid becomes hot, there iſſue from it ſome bubbles of nitrous gas, not in great plenty. The mixed acid acts calmly and ſlowly: this acid, however, takes at firſt a yellow colour, which changes to an orange, and becomes gradually deeper, till it be changed into a very dark brown red. When the ſolution is ended, particles of reddiſh and black ſand are found at the bottom of the retort, and are ſeparated by decanting off the liquor; the ſaturated liquor gradually depoſites ſmall irregular cryſtals of a duſky colour, which are a combination of the acid with platina. The ſolution of platina is among the higheſt coloured of metallic ſo-

lutions. Though it appears to be of a deep brown colour, yet when it is diluted in water, the fluid takes at firſt an orange colour, which in a ſhort time becomes yellow, and very like the ſolution of gold: it communicates to animal matters a blackiſh brown tinge; which, however, is by no means purple. M. Baumé ſays, that platina, melted in the focus of a burning glaſs, and diſſolved in aqua-regia, never takes a brown colour, like that of platina in grains; and that the ſolution is of a deep orange yellow.

Macquer aſſerts, that on evaporating the ſolution of platina, and ſuffering it to cool, cryſtals are obtained from it, much larger, and much more beautiful, than thoſe which it depoſites of itſelf when ſaturated. Lewis, on ſuffering this ſolution to evaporate in the open air, obtained cryſtals of a deep red colour, tolerably large, of an irregular form, and pretty like the acid of benzion, but thicker. Bergman deſcribes them as having an octohædral form. This ſalt is tart, but not very cauſtic; it melts with heat, gives out its acid, and leaves, as a reſidue, a dark grey oxide. The concentrated ſulphuric acid produces in it a dark-coloured precipitate, which is no doubt ſulphate of platina. The muriatic acid likewiſe produces in it, in the courſe of time, a yellowiſh ſediment.

Alkalis and ſalino-terrene matters decompoſe the ſolution of platina, and precipitate the metal in the ſtate of oxide. Carbonate of potaſh produces an orange precipitate in the ſolution of platina. This precipitate is not a pure oxide of platina. Meſſrs Macquer and Baumé have obſerved, that it owes its colour to its containing a certain quantity of acid. It is therefore to be conſi-

dered

dered as a mixture of oxide of platina with muriate of potaſh, or a kind of triple ſalt. A proof of this opinion is, that when this precipitate is waſhed with hot water, the fluid acquires a colour by diſſolving the ſalt of platina, and the reſidue is pure oxide of platina, of a grey colour. Fixed alkali, boiled on this precipitate, inſtantly deprives it of its colour, leaving an oxide of platina of a grey white pearl colour, according to the experiments of M. Baumé. That chemiſt made himſelf certain, that the precipitate of platina is ſoluble in alkali; for, on pouring a ſolution of the metal into a hot ſolution of carbonate of potaſh, he found no precipitate produced: and this ſolution, precipitated by fixed alkali, always retains on this account a deep colour; and platina may be eaſily obtained by evaporating it to dryneſs. Margraff diſcovered, that ſoda does not precipitate the ſolution of platina: but Bergman has obſerved, that, on putting into it a great quantity of this alkali, there is a precipitate ſpeedily enough produced.

The alkaline Pruſſiates form a copious blue precipitate, which, according to M. Baumé, is owing to the iron contained in the alkali; for if the Pruſſiate of potaſh be purified by the proceſs which that chemiſt deſcribes for the purpoſe, from the iron which it contains, it no longer affords any more than a few particles of blue, which are owing to the metal's ſtill retaining a ſmall portion of iron. Bergman aſſerts, that an alkaline Pruſſiate, highly ſaturated and very pure, does not precipitate the ſolution of platina; and that this metal is the only one not liable to be precipitated

by

by this re-agent; and therefore propoſes it for ſeparating the iron which is always in union with platina.

Cauſtic ammoniac produces an orange precipitate in the ſolution of platina. This precipitate is almoſt entirely ſaline; for water diſſolves moſt part of it, taking a colour like that of the ſolution of gold. After the water has acted on this precipitate, there remains a blackiſh ſubſtance, which appears to be ferruginous. One eſſential difference between the precipitate of platina and that of gold by ammoniac, is, that the former is not fulminating like the latter.

Nut-gall, or rather the gallic acid, produces, in the ſolution of platina, a deep green precipitate, which becomes gradually pale by reſt.

All precipitates of the ſolution of platina obtained by alkaline matters, are incapable of being vitrified, and of colouring glaſs by furnace-fires. In the attempts made by Meſſrs Lewis and Baumé to accompliſh this, the platina was always reduced to grains, which were arranged in ramifications, or a kind of chequer work. Platina may be obtained in a ſort of button, by expoſing theſe precipitates, to heat, together with ſome reductive fluxes, ſuch as borax, cream of tartar, glaſs, &c. Meſſrs Macquer and Baumé, melted, in five and thirty minutes, at a forge-fire, blown by two ſtrong bellows, a precipitate of platina mixed with theſe fluxes. They obtained in a hard blackiſh glaſs, like bottle-glaſs, a brilliant button of platina, which appeared to have been in fuſion. This button was not ductile: it broke into two pieces; in conſequence of which it was obſerved to be hollow within. It was nearly of the ſame hardneſs with forged iron, and made deep ſcratches in gold,

gold, in copper, and even in iron. Notwithſtanding what we have obſerved of precipitates of platina, as not being liable to vitrify or mix with glaſs, Baumé melted them into a vitriform matter by two different proceſſes. The precipitate of platina, mixed with calcined borax and a very fuſible white glaſs, and expoſed for ſix and thirty hours to the heat of the hotteſt place of a furnace for pottery, afforded him a greeniſh glaſs, inclining to yellow, and containing no globules of reduced metal. This glaſs being treated anew with cream of tartar gypſum, and potaſh, was thoroughly melted, but contained ſmall globules of platina diſperſed through it. M. Baumé ſéparated them by waſhing, and found them to be ductile. He then, in conjunction with M. Macquer, expoſed precipitate of platina in the focus of the ſame burning-glaſs with which they had melted the metal. The precipitate emitted a very thick luminous ſmoke, which diffuſed a ſtrong ſmell of nitro-muriatic acid: it loſt its red colour, and reſumed the natural colour of platina; and it melted into a gloſſy ſparkling button: which button was an opaque vitreſcent matter, of an hyacinth colour on the ſurface, and blackiſh internally, and may be conſidered as a real glaſs of platina. It is, however, neceſſary for us to obſerve, that the ſaline matters with which it was impregnated, muſt, without doubt, have contributed to its vitrification.

The precipitate of platina does not appear to be ſoluble in ſimple acids; but it diſſolves readily in the nitro-muriatic acid, to which it communicates only an orange colour; never a brown like platina in grains.

The ſolution of platina is not precipitated by alkaline or perfect neutral ſalts; but ammoniacal muriate produces

duces in it a copious precipitate. We know not yet well what paſſes on this occaſion. It appears, that the orange colour obtained by pouring a ſolution of ammoniacal muriate into a ſolution of platina, is a true ſaline ſubſtance entirely ſoluble in water. This precipitate poſſeſſes one property of no ſmall importance, which was firſt obſerved by M. de Liſle; it melts alone, without any addition, in a good ſtrong furnace-fire, or in the fire of a common forge. The platina melted by this proceſs is a ſparkling button of conſiderable denſity and cloſeneſs of grain, but not malleable, and not liable to become ductile, unleſs when expoſed to a pretty ſtrong heat. Macquer is of opinion, that the ſame thing takes place in this inſtance of fuſion, as when grains of platina are expoſed by themſelves to the action of a ſtrong fire; and that what is affected is nothing but an agglutination of the particles ſoftened by the heat; which being much more minute than grains of platina, are brought more completely into contact with each other than thoſe grains can be; in conſequence of which, though no real fuſion take place, yet the grain of the metal is much cloſer in this than in the former caſe. It appears, however, that as platina in grains is liable to melt in a burning-glaſs, and acquires, by that means, conſiderable ductility; ſo the precipitate of this metal produced by ammoniacal muriate, being in a ſtate of extreme diviſion, may be alſo melted; and if the precipitate acquire not by fuſion the ſame ductility with platina melted by the rays of the ſun, this is perhaps owing to its ſtill retaining ſome matter which was intermixed with it when it was precipitated; but may be ſeparated from it by the action of fire.

Margraff

Margraff diſſolved platina in *aqua-regia*, conſiſting of ſixteen parts of nitric acid, with one of ammoniacal muriate. On diſtilling this ſolution to dryneſs, and even till the retort became red-hot, a dark red ſalt was ſublimated, and the reſidue was a reddiſh powder. It is not known whether the ſolution of platina in ſimple *aqua-regia*, that is, *aqua-regia* conſiſting of nitric and muriatic acid, would afford the ſame ſublimate by diſtillation.

Meſſrs Margraff, Baumé, and Lewis, mixed the ſolution of platina with ſolutions of the other metallic ſubſtances. From theſe experiments it appears, that almoſt all metals precipitate platina in a brick-red or a brown powder; and that, agreeably to what happens to moſt other metals, none of theſe precipitates poſſeſſes the properties of a metal. In this there is an analogy between gold and platina: with tin, however, platina does not give a purple, but a brown precipitate, inclining to red. With reſpect to the effects which the ſeveral metallic ſolutions produce on the ſolution of platina, we ſhall only obſerve, that ſolutions of biſmuth and lead by the nitric acid, of iron and copper by any of the acids, and of gold by *aqua-regia*, produce, none of them, any precipitate in the ſolution of platina, according to Margraff: but again, ſolutions of arſeniate of potaſh, of nitrate of zinc, and nitrate of ſilver, are capable of precipitating the ſolution of platina: with the firſt, it yields a ſcanty cryſtallized precipitate of a beautiful golden colour; with the ſecond, an orange-red matter; and with the third, a yellow matter. Theſe different precipitates have not been yet carefully examined; nor is it known by what decompoſition they are produced.

Scarce any of the neutral ſalts acts upon platina. Margraff heated platina with ſulphate of potaſh and ſulphate of ſoda at a ſtrong fire. The ſalts were melted, but the platina remained in grains without alteration; only it communicated a faint reddiſh colour to the ſaline matters, which it was enabled to do, no doubt, by means of the iron mixed with it.

Nitre, according to the experiments of Lewis and Margraff, alters platina in a ſingular manner. No detonation takes place when a mixture of theſe two ſubſtances is caſt into a crucible; but when a mixture, conſiſting of one part of platina and two of nitre, is expoſed for a conſiderable time to an intenſe heat, as Lewis expoſed it for three days and three nights ſucceſſively, the metal takes a ruſty appearance. If this mixture be boiled in water, the fluid diſſolves the alkali, which carries with it a browniſh powder; and the platina ſeparated by this waſhing is found to be one third leſs than the original quantity. The brown powder may be ſeparated from the alkali by filtration. This powder appears to be a kind of oxide of platina, mixed with a little oxide of iron. Lewis cauſed it to take a whitiſh grey colour, by diſtilling it many times ſucceſſively with ammoniacal muriate. Margraff repeated this valuable experiment, and has added two important facts; platina combined with alkali of nitre, and diluted in a certain quantity of water, forms a jelly: A portion of the metal ſeparated from this jelly, by dilution in water and filtration, takes a black colour like pitch.—From theſe circumſtances, it appears, that the platina ſuffers in this proceſs ſome great alteration; and it is wiſhed, that theſe experiments were farther proſecuted,

in

in order to determine whether by repeated oxidation with nitre, this metal might be wholly reduced to a brown powder; as alſo to aſcertain the ſtate of the platina thus oxidated.

Muriate of potaſh or ſoda, borax or earthy ſalts, produce, none of them, any alteration on platina, nor contribute in any degree to its fuſion. Ammoniacal muriate ſublimated with this metal affords a ſmall quantity of *martial flowers*, on account of the iron contained in the platina.

Chemiſts have not agreed with regard to the mutual action of arſenic and platina. Scheffer firſt gave out that arſenic acted as a flux to platina; but the experiment ſucceeded only in part with Lewis, and did not ſucceed at all with Margraff, Macquer, and M. Baumé. This experiment has been ſince repeated; and it is now eſtabliſhed as a fact, that arſenic does cauſe platina to melt very readily; and that the mixture produced by this fuſion is exceedingly brittle. When the arſenic is ſeparated by roaſting, and the perfect metal expoſed to a continued heat, the latter becomes ductile. By this proceſs, M. Achard and M. Morveau have accompliſhed the making of crucibles of platina, by melting it a ſecond time in moulds.

No attempt has yet been made to combine cobalt, nickel, or manganeſe with platina.

This perfect metal enters readily enough into combination with biſmuth; which renders it fuſible, and the more ſo the greater the quantity of the biſmuth.—This mixture is brittle; it becomes yellow, purple, and blackiſh in the air; it cannot be cupelled without the greateſt

greateſt difficulty; the maſs has always very little ductility.

Platina eaſily melts with antimony: the product is a brittle metal with facets, from which the antimony may be ſeparated by the action of fire, but which ſtill retains, whatever means may be uſed for its ſeparation, ſo much of the antimony as is ſufficient to deſtroy the gravity and ductility of the platina.

Zinc renders platina very fuſible, and combines very eaſily with it; the mixture is brittle, and reſiſts the file: it inclines to blue in colour, when the platina is more copious than the zinc. Theſe two metallic matters are ſeparable by the action of fire, which volatizes the zinc; platina, however, always retains a little of it.

Platina does not combine with mercury; and though triturated together for hours, theſe two metallic matters cannot be formed into an amalgam. It is alſo known, that in America mercury is employed to ſeparate platina from gold. Various intermedia, ſuch as water, which Meſſrs Lewis and Baumé made uſe of, and nitro-muriatic acid, which M. Scheffer employed, contribute nothing to the union of platina with mercury. It reſembles iron in this property, as alſo in colour and hardneſs.

Platina readily combines with tin. The mixture is very fuſible, and melts into a flowing liquid. It is ſo brittle as to break even by a blow, when the two metals are united in equal parts. When tin is in the proportion of twelve or more parts to one of the platina, the mixed metal is then ſufficiently ductile; but its grain is coarſe, and it becomes yellow in the air. The platina diminiſhes the ductility of the tin in an amazing degree, and it does not appear that any advantage can be derived

ved from this mixture. However, when well poliſhed, it remains long in the air without ſuffering alteration. Lewis, to whom we owe moſt of our knowledge concerning the mixtures of platina, oxidated the metal, and diſſolved it in muriatic acid by means of the tin.

Lead and platina combine very well by fuſion; but a ſtronger fire is requiſite to melt them than to melt the foregoing mixture. The platina deſtroys the ductility of the lead. From the combination of theſe two metals there reſults a mixed metal, nearly of a purple colour, more or leſs brittle according to the proportions of the platina, ſtriated and granulated in its fracture, and liable to alter very readily in the air. Cupellation of lead was one of the moſt important experiments to be made on platina; for this was the only operation that could be expected to ſeparate from it ſuch extraneous matters as it might contain. Lewis, and ſeveral other chemiſts, in vain attempted to cupel platina in common cupelling furnaces, whatever the degree of the heat employed in thoſe furnaces. On account of the exceſs of the lead, it is vitrified and abſorbed in the beginning of the operation; but the platina ſoon becomes fixed, and the progreſs of the operation ſtops; the perfect metal remains in union with a portion of the lead, and is without ductility. Meſſrs Macquer, and Baumé effected the complete cupellation of platina, by expoſing an ounce of this metal with two ounces of lead to the heat of the hotteſt place of the porcelain-furnace at Seves. The wood fire that they kindled in it burned for fifty hours uninterruptedly. At the end of that time the platina lay flat upon the cupel: its upper ſurface was dark and ſhrivelled, and was eaſily ſeparable from the reſt; its

under ſurface was brilliant; and what is of moſt importance, it was now ſufficiently malleable. Theſe chemiſts aſcertained, by every poſſible means, the platina to be very pure, and unmixed with lead. M. de Morveau likewiſe ſucceeded in cupelling a mixture of a dram of platina with two drams of lead in Macquer's wind-furnace. This operation, which was four times repeated, laſted eleven hours. M. de Morveau obtained a button of platina, not adheſive, uniform, coloured like tin, ſomewhat rough, weighing exactly a dram, and not ſubject to the attraction of the magnet. This is therefore a convenient proceſs, by which platina may be melted into plates that may be wrought in the forge; and of conſequence made into various utenſils of great value for their hardneſs and unalterability. M. Baumé likewiſe obſerved it to poſſeſs this valuable property, that different pieces of it may be ſoldered and wrought together like iron, without the intervention of a third metal. After heating two pieces of platina that had been cupelled in the furnace of Seves to a white red, he put the one upon the other, and ſtruck them with a hammer; and by this management the two pieces were as ſufficiently and ſolidly ſoldered as any two pieces of iron could have been. It is not neceſſary that we ſhould inſiſt long on this experiment, to ſhow what advantages the arts may derive from it.

Lewis could not obtain a mixture of forged iron and platina. A mixed metal of this kind would poſſeſs at once the hardneſs of tempered ſteel, and a conſiderable degree of ductility; it would not at leaſt be ſo brittle as ſteel. The Engliſh chemiſt, whom we have cited, melted a mixture of caſt iron and platina. The alloy was

ſo

ſo hard that the file could make no impreſſion upon it: it had little ductility; but when red-hot it broke with a ſmooth fracture.

Platina communicates hardneſs to copper, and melts with it eaſily enough. This mixture is ductile when the proportion of the copper is three or four times that of the platina. It takes a fine poliſh, and is not liable to be tarniſhed in the courſe of ten years.

Platina deſtroys in part the ductility of ſilver, increaſes its hardneſs, and tarniſhes its colour. The mixture is very difficult to melt. The two metals are ſeparable by fuſion and reſt. Lewis obſerved, that the ſilver melted with platina is daſhed with a kind of exploſion againſt the ſides of the veſſel. This phænomenon ſeems to be effected ſolely by the ſilver; for M. d'Arcet ſaw that metal burſt bowls of porcelain, in which it was incloſed, and ſpring out of thoſe veſſels in conſequence of the action of the fire upon it.

A very ſtrong heat is requiſite to make platina combine properly with gold. It greatly alters the colour of that metal, at leaſt if its quantity be not very ſmall; for inſtance, a forty-ſeventh part of platina, and all proportions under that, produce but little alteration on the colour of gold. Platina ſcarce diminiſhes the ductility of gold; it is even one of thoſe metals which have the leaſt influence on gold this way. The gravity of platina being greater than that of gold, might be an encouragement to fraud; and the Spaniſh miniſtry have therefore prohibited the exportation of the metal. However, ſince chemical methods of diſtinguiſhing when gold is alloyed with platina have been diſcovered, theſe fears are now vain; and it is much to be wiſhed, that pla-

tina were permitted to be an article of commerce, that ſo we might obtain the uſe of a new metal, which promiſes to be ſo ſerviceable.

The ſolution of ammoniacal muriate poſſeſſes, as we have obſerved, the property of precipitating platina. When, therefore, gold is ſuſpected to be alloyed with platina, a ſolution of it in *aqua-regia* may be aſſayed with a ſolution of ammoniacal muriate. If it contain any platina, however little, an orange or reddiſh precipitate will be produced: if there is no precipitate produced, this circumſtance is a proof that the gold contains no platina. If the valuable properties of platina ſhould one day render it more ſcarce and more eſteemed than gold, neither will we then be in danger of having alloys of gold with platina impoſed upon us, for pure platina; for a ſolution of ſulphate of iron, which poſſeſſes the property of precipitating a ſolution of gold without affecting platina, might be uſed as a teſt to prevent ſuch impoſition. A plate of tin immerſed into a ſolution of platina, alloyed with gold, would likewiſe detect the preſence of the latter metal, by becoming coated with a purple precipitate; whereas platina by itſelf gives it only a dirty brown colour, inclining to red. Beſides, the precipitate of platina does not colour glaſs; whereas the precipitate of gold gives it a purple colour.

All thoſe properties of platina which we have examined prove it to be a peculiar metal. Its poſſeſſing in ſo low a degree the properties of ductility and fuſibility, which has been conſidered by ſome perſons as a ſtrong objection againſt this opinion, is not ſufficient to juſtify the refuſing it that character which we have aſcribed to it: for perhaps the difference between the fuſibility of

platina

platina and that of forged iron, is not ſo conſiderable as the difference between the fuſibility of forged iron and that of lead: and its inductility may be conſidered as owing to its having never yet been completely melted. With reſpect to the opinion of thoſe philoſophers who think platina a natural alloy of gold with iron, however ingenious and ſatisfactory it may appear, it cannot be admitted till ſuch time as platina ſhall be ſeparated by an exact analyſis into theſe two metals, and till it be better imitated than at preſent by an artificial mixture of gold with iron. Laſtly, Macquer has urged a very ſtrong objection againſt this laſt opinion, by obſerving, that the more thoroughly platina is purified from iron, the more remote does it appear in its exterior characteriſtics and properties from the nature of gold.

It may be eaſily conceived with what advantages the uſe of this precious metal in commerce would be attended, as it poſſeſſes, with the durability of gold, nearly the hardneſs of iron, and is proof againſt the action of the moſt violent fire, and the moſt concentrated acids. It would, doubtleſs, be of the higheſt utility both to chemiſtry and to the arts.

The denſity and opacity of platina render it valuable for the conſtruction of optical inſtruments. The Abbé Rochon has conſtructed a mirror of this metal, the effect of which greatly ſurpaſſes that of the mirrors made of ſteel and other metals. Like other metallic mirrors, it reflects but a ſingle image; but is at the ſame time as unchangeable as the mirrors of glaſs. H.

CHAP. XXIII.

Genus VI. *Bitumens in general* *.

BITUMENS are combuſtible matters, either ſolid, ſoft, or fluid, of a ſtrong, acrid, aromatic ſmell, and apparently of a much more compound nature than any of the bodies belonging to the mineral kingdom which we have yet examined. They are found either in ſtrata in the bowels of the earth, or dropping from rocks, or ſwimming on the ſurface of waters. They generally burn with a rapid flame when heated in contact with air, like thoſe matters formed by the organs of animals and vegetables, which are called *oils*. They do not admit of being ſo exactly analyſed as earthy, ſaline, or metallic matters; for the action of fire alters them in a ſingular manner, extracting from them principles, which, as they are volatilized, re-act on each other. In this reſpect,

* The reader may here recollect, that we divided combuſtible mineral matters into *five* genera; diamond, hydrogenous gas, ſulphur, metals, and bitumens.

ſpect, there is an analogy between bitumens and vegetable and animal ſubſtances. They afford, by diſtillation, an odorate water phlegm, more or leſs coloured and ſaline; an acid generally concrete; ſometimes ammoniac; and oils, which, though at firſt light, become more and more thick and coloured, as the diſtillation is continued, and the ſtrength of the fire increaſed. After this analyſis, there remains a coal of a greater or a leſs bulk, denſe, light, porous, brilliant, or compact, according to the particular nature of the bitumen. This analyſis is a proof that theſe inflammable bodies have originated from animal or vegetable matters; as we ſhall relate more at large when we give the hiſtory of their properties.

Bitumens ſuffer ſome alterations from light; when fluid, their colour is rendered deeper, and their ſmell modified in tranſparent veſſels. The air renders them thicker by a gradual evaporation of the moiſture which they contain; and the drier the atmoſphere, ſo much the ſpeedier is this evaporation. Their odorous principle, or ſpiritus rector, is at the ſame time gradually diſſipated; and from fluid they become by degrees tenacious and ſolid. But this latter alteration requires a long ſeries of years.

When bitumens are boiled in water, the water does not diſſolve them, but extracts their ſpiritus rector, and afterwards exhales that odour which is peculiar to them. It would therefore appear, that water has a greater affinity with their odorous principle than the oily matter of the bitumen; and perhaps theſe bodies might thus be entirely deprived of ſmell.

No experiments have been made to determine in

what manner the ſalino-terrene ſubſtances act upon bitumens. Both lime and pure alkalis, however, appear capable of combining with theſe combuſtible matters, and forming with them compounds ſoluble in water, which are called *ſoaps*.

We know not in what manner the mineral acids are capable of acting on bitumens. Probably they would either diſſolve or burn them like oils, according to the ſtate of concentration in which they happened to be.

Neither has the action of neutral ſalts, hydrogenous gas, ſulphur, or metals, on bitumens, been examined; and the chemical properties of theſe bodies are in general but very little known. This is an unbeaten path; and very uſeful diſcoveries might here be made.

Naturaliſts have been at much more pains in ſtudying the origin and formation of bitumens, than chemiſts in analyſing them. Several different opinions have been entertained on this head. Some have thought combuſtible bodies to belong properly to the mineral kingdom, and to hold in it the ſame rank which oils and reſins hold among organic matters. But this fancied analogy, however plauſible, does not agree with facts; for we know of no ſubſtance in the mineral kingdom of an oily nature. And that opinion which aſcribes the origin of bitumens to vegetable matters buried under ground, and altered by the action of mineral acids, has been much more generally received than the former. Every fact, indeed, concerning bitumens, concurs to prove, that they have been produced from organic matters. Near them are found a great many matters

ſtill

ſtill retaining an organical form. Beſides, their chemical properties are thoſe of ſubſtances formed by the action of vital powers; and they have been imitated to a certain degree by the combination of oils with concentrated ſulphuric acid. In the chemical hiſtory of vegetable matters, we ſhall ſee, that this acid brought into contact with eſſential oils, renders them hard and black, and communicates to them a ſtrong pungent ſmell like that of bitumens. But are theſe bodies formed ſolely from vegetables buried under ground, as has been aſſerted by moſt naturaliſts? Do animal matters, in the ſame ſituation, never contribute to the formation of bitumens? One objection which may be urged againſt the opinion that repreſents bitumens as originating ſolely from particular vegetable bodies, is the great diſproportion between the maſſes of bitumen found in the earth, and the wood or trees found near them, and ſtill more the trifling quantity of oily matters contained in thoſe vegetable ſubſtances. And farther, the abundance of theſe combuſtible bodies, in places where ſcarce any remains of vegetable matters appear, but the exuviæ of animals are found in heaps above the bitumens, leads us to think, that theſe latter organic beings have contributed greatly, perhaps more than vegetables, to the formation of certain bituminous ſubſtances. We may likewiſe obſerve, that the ſucceſſive ſtrata, in which ſome continuous maſſes of bitumen are found arranged in the interior parts of the globe, indicate thoſe maſſes to have been depoſited ſlowly, and by water; and that the date of their formation correſponds to the period in which ſuch immenſe maſſes of ſhells, and other marine bodies, have been formed by the ſea. They have therefore been in

a fluid ſtate, and have become hard in the courſe of time, in conſequence of being expoſed to the action of ſaline or other ſubſtances, abounding in the interior parts of the earth. Such is the opinion which M. Parmentier, Member of the College of Pharmacy, has embraced concerning the origin of mineral coal, in a Memoir which he read before that Society at the opening of their courſe of lectures. The oils and fats of marine animals appear therefore to be part of the materials which Nature employs in the formation of certain bitumens: and there are others again, the origin of which is evidently from vegetables, and which have been produced from reſins or eſſential oils, buried and altered in the earth.

The number of bitumens is very conſiderable. Naturaliſts have arranged them under various genera. Conſidered chemically, they merit rather to be conſidered as ſo many ſpecies; for the ſame chemical characteriſtics are common to them all. Some of them are liquid; others of a ſoft conſiſtency: there are others ſolid, and among theſe ſome ſo hard as to be ſuſceptible of poliſh: others friable. We know of five ſpecies, conſiderably diſtinct from one another. Theſe are amber, the aſphaltes or bitumen of Judæa, jet, pit-coal, and petroleum; and we are to give their hiſtory. Ambergris we do not conſider as a bitumen but, as an animal product.

CHAP.

CHAP. XIV.

Species I. *Of Amber, and its Acid.*

THIS ſubſtance is, in external appearance, one of the moſt beautiful of bituminous matters: it exiſts in irregular fragments of a yellow or brown colour, either tranſparent or opaque, and compoſed of layers or ſcales. It takes a very fine poliſh. After being rubbed for ſome time, it becomes electric, and attracts ſtraws. The ancients, who knew amber to poſſeſs this property, gave it the name of *electrum*, and hence the word *electricity*.

The conſiſtency of this bitumen is pretty hard, nearly equal to that of certain ſtones; which has induced ſeveral authors, particularly Hartman, a naturaliſt who lived about the end of the laſt century, to rank it among precious ſtones. It is, however, brittle and friable.—When pulverized, it diffuſes an agreeable enough ſmell. It is often found to contain inſects in a good ſtate of preſervation; a circumſtance which proves that it has been in a liquid ſtate, and in that ſtate has incloſed theſe bodies.

bodies. It is uſually buried under ground, at various depths; it is found under coloured ſand, in ſmall incoherent maſſes, on beds of pyritous earth: above it, is found wood containing a blackiſh bituminous matter. From theſe circumſtances, it is thought to be formed from a reſinous ſubſtance, altered by the ſulphuric acid of the pyrites. It alſo floats on ſea-coaſts. It is gathered on the ſhores of the Baltic in Ducal Pruſſia. The hills of Provence, near the town of Siſteron, the marquiſate of Ancona, and the duchy of Spoletto in Italy; Sicily, Poland, Sweden, and various other countries, likewiſe afford this ſubſtance. This bituminous ſubſtance is diſtinguiſhed into a good many varieties, by its colour, contexture, tranſparency, or opacity. Wallerius reduces them to the following

Varieties.

1. White tranſparent amber.
2. Pale yellow tranſparent amber.
3. Citron yellow tranſparent amber.
4. Tranſparent amber of a golden yellow colour. *Chryſo-electrum* of the ancients.
5. Dark red tranſparent amber.
6. White opaque amber. *Lucelectrum.*
7. Yellow opaque amber.
8. Brown opaque amber.
9. Amber coloured green or blue by extraneous matters.
10. Veined.

Were we to take notice of all the accidental appearances which are obſerved in the interior parts of pieces of amber, we might extend theſe varieties to a much more conſiderable

conſiderable number. But, in regard to the price demanded for pieces of amber, on account of their ſize, their tranſparency, and their containing inſects in a fine ſtate of preſervation, it is proper to warn people that they may not be impoſed upon; as many perſons know how to render it tranſparent, or colour it at pleaſure, as well as to ſoften it to a degree, that extraneous bodies may be introduced into it. Wallerius informs us, that gold-coloured amber always owes its tranſparency to nature; and that amber made tranſparent by art is always of a pale colour.

Although it be highly probable, that this bitumen originates from reſinous vegetable matters; yet ſeveral naturaliſts have entertained different opinions concerning its formation. Some have thought it to be urine of certain quadrupeds, congealed and hardened; others have imagined it a juice of the earth, extracted and carried off by the ſea, which being driven by the waters on the ſhore, is there dried and hardened by the rays of the ſun. This claſs of naturaliſts call it a peculiar mineral juice. Such was the opinion of an ancient naturaliſt of the name of Philemon, quoted by Pliny. It has been in modern times revived by George Agricola. Frederick Hoffman thought it to conſiſt of a light oil, ſeparated by heat from bituminous wood, and thickened with the acid of vitriol. This opinion of Hoffman's, however, cannot be admitted: it is not eaſy to imagine how an oil ſeparated in the bowels of the earth could happen to contain animals that are known to live only on the ſurface. Till of late, amber was thought to be a reſinous juice, which dropped at firſt in a fluid ſtate from certain trees: this juice, it was thought, having been,

been, by ſome convulſion of the earth, buried under ground, had been there hardened, and impregnated with ſaline mineral vapours. But there is no appearance of its having been altered by concentrated acids; for experience ſhows, that ſuch acids would have blackened it, and reduced it to a carbonaceous ſtate. Pliny thought amber to be nothing but the reſin of the pine-tree condenſed by cold. M. Girtanner thinks it to be a vegetable oil concreted by the acid of the ants. The *formica rufa* of Linnæus is, according to this author, the ſpecies which prepares it. Theſe inſects inhabit old foreſts of fir-trees, where there is foſſile amber found, which is ductile, like liquid wax, but becomes dry in the air.

A conſiderable degree of heat is neceſſary to liquify amber: it becomes ſoft, and ſwells a good deal. When heated in contact with air, it takes fire, and diffuſes a very thick and ſtrong-ſmelling ſmoke. Its flame is yellowiſh, variegated with green and blue. After its combuſtion there remains a ſparkling black coal, which affords, by incineration, a very ſmall quantity of brown earth. Bourdelin, in his Memoir on Amber (*Academy*, 1742), relates, that he obtained only eighteen grains of this earth from two pounds of amber burnt in a roaſting pot. Half a pound of the ſame bitumen, burnt and calcined in a crucible, afforded, in a ſecond operation, twelve grains of earthy reſidue; from which, by means of the magnet, he extracted iron.

Amber diſtilled in a retort, by a fire gradually applied, gives at firſt a phlegm which takes a red colour, and is plainly of an acid nature. This acid ſpirit retains a ſtrong ſmell of amber; there paſſes next a volatile acid ſalt, which cryſtallizes in the neck of the retort

into ſmall white or yellowiſh needles; next after this ſalt, there comes a white light oil of a very lively ſmell. This oil gradually takes a colour as the fire becomes ſtronger, and at length becomes brown, blackiſh, thick, and viſcid, like empyreumatic oils. While theſe two oils are paſſing, there is a certain quantity of volatile ſalt ſublimated, which becomes gradually more and more coloured. After the operation, there remains in the retort a black maſs fixed on its bottom, brittle, and ſimilar to the bitumen of Judæa. George Agricola made this obſervation three centuries ago, on the reſidue of diſtilled amber. When the operation is conducted with a moderate fire, judiciouſly applied, and the quantity of the amber not inconſiderable, theſe products may be obtained ſeparately by changing the receiver. They are commonly received all in one receiver, and afterwards rectified by a moderate heat. The acid loſes its colour in part by this rectification. The oil, the reaſon of which becoming black towards the end of the operation, is becauſe it carries with it a portion of carbonaceous matter, and becauſe the acid re-acts on its principles,—may be rendered very white and very light by repeated diſtillation. Rouelle, the elder, has given a very good proceſs for obtaining it in this ſtate by one operation. Put the oil with water into a glaſs alembic, and diſtil it by the heat of boiling water; the pureſt portion, being the only part of the oil volatile at ſuch a degree of heat, on account of its levity, paſſes with the water, and is collected above it. To preſerve it in this ſtate, it muſt be put up in ſtone-veſſels; for in glaſs-veſſels, the rays of light which paſs through that matter, give it, in a certain time, a yellow, or even a brown colour.

This

This analyſis proves amber to conſiſt of a great quantity of oil rendered concrete by an acid. It contains likewiſe a very ſmall quantity of earth the nature of which has not been yet examined, and a few particles of iron.

The oil of amber appears to be much of the ſame nature with eſſential oils. It is equally volatile, and has the ſame ſmell. It is very inflammable; and appears to be fit for forming ſoaps with alkalis.

The volatile ſalt of amber was for ſome time conſidered as an alkaline ſalt. Glaſer, Le Fevre, Charas, and John-Maurice Hoffman, profeſſor at Altdorf, were of this opinion. Barchuſen, and Bouldoc the father, both in the laſt century, were the firſt, who aſcertained the nature of this ſalt to be acid. Their diſcovery has been unanimouſly received by ſucceeding chemiſts; who have not agreed, however, concerning the particular nature of that acid. Frederick Hoffman, becauſe amber is found in Pruſſia under ſtrata of matters among which pyrites are copiouſly intermixed, has inferred its ſalt to be vitriolic acid. Neumann appears to be of the ſame opinion. Bourdelin, in the Memoir above quoted, relates ſeveral experiments, by which he ſought to aſcertain the nature of this ſalt. He firſt obſerves, that the ſalt of amber, extracted by diſtillation, however white and pure it may appear, always contains an oily matter; to this oily ſubſtance, no doubt, it owes its ſmell, and that kind of combuſtibility which it conſtantly exhibits when caſt on burning coals. He attempted by various means to ſeparate that ſubſtance. We ſhall have occaſion to ſee, when we come to examine the nature and properties of alkohol, that *it* could not ſerve his purpoſe.

He

He ſucceeded no better by digeſting fixed alkali over amber, with a view to ſeparate from it this oily matter; the alkali only diſſolved a little of the bitumen, and acquired a ſaltiſh lixivial taſte, like that of ſea-ſalt. Laſtly, the beſt means which Bourdelin could find for combining the acid of amber entirely purified from oily matters with fixed alkali, was to detonize a mixture, conſiſting of two parts of nitre, with one of the bitumen. The reſidue, after this detonation, he lixiviated with diſtilled water. The lixivium was of an amber colour: it produced, in the ſolution of ſilver, a white curdled precipitate; in the ſolution of mercury, a precipitate of the ſame colour. It decompoſed, in like manner, ſeveral other metallic ſolutions; but Bourdelin conſidered only theſe two precipitations as concluſive facts. He underſtood them as indicating the acid of amber to be the ſame with that of marine ſalt; for theſe phænomena are preciſely the ſame with thoſe which the acid of marine ſalt produces in the nitric ſolutions of mercury and ſilver. The lixivium of the reſidue which remained after the detonation of amber with nitre, being evaporated in the air, afforded a mucilaginous matter, in the middle of which oblong ſquare, cryſtals were by degrees depoſited; which, by their form, their ſaltiſh taſte, their decrepitation on burning coals, and ſtill more their effervеſcence, which was conſiderable, and the ſmell of muriatic acid which exhaled from them, when concentrated ſulphuric acid was poured upon them, indicated, in his opinion, that they conſiſted of muriatic acid, with a baſe of nitre. Notwithſtanding this analyſis, which, conſidering the time when Bourdelin made his experiments, is very accurate, the

chemiſts who have ſince examined the ſalt of amber have not found it to bear any reſemblance to the muriatic acid. Bergman, who ſeems to have adopted this opinion, gives the following account of the properties and the elective affinities of this ſalt. The ſuccinic acid, or acid of amber, extracted by diſtillation, and purified by repeated ſolutions and cryſtallizations, forms, with potaſh and ammoniac, cryſtallizable and deliqueſcent neutral ſalts. With ſoda, it affords a ſalt which does not attract the moiſture of the atmoſphere: with barytes and lime, it forms ſalts that are ſcarce ſoluble: with magneſia, a thick gum-like matter. It diſſolves metallic oxides; and the ſuccinates produced by theſe ſolutions are moſtly cryſtallizable and permanent.

Barytes, lime, and magneſia, according to him, ſeparate the acid of amber from alkalis. Barytes decompoſes ſuccinates of lime and magneſia; and lime-water precipitates magneſia from its combination with this acid.

The chemical properties of this bitumen have been no farther examined. We know not even how the acids would act upon it. Frederick Hoffman affirms, that it may be entirely diſſolved in a lixivium of cauſtic alkali, and in ſulphuric acid. We know, too, that the eſſential oil of amber combines with cauſtic ammoniac, and forms with it, ſimply by mixture and ſhaking, a ſort of liquid ſoap, of a milk-white colour, and of a very pungent ſmell, known in pharmacy by the name of *Eau de luce*: and laſtly, this ſame oil is known to diſſolve ſulphur by the heat of a ſand-bath, thus compoſing a medicine, called *ſuccinated balſam of ſulphur*.

Amber is uſed in medicine as an antiſpaſmodic: it has

has been recommended for hyſteric and hypochondriac caſes, a ſuppreſſion of the *menſes*, gonorrhœa, fluor albus, &c. It is made uſe of after being waſhed with warm water, and levigated to a fine powder. It is uſed in fortifying and reſolvent fumigations, by throwing the powder on a hot brick, and directing the ſmoke to the place upon which you wiſh it to act. The volatile ſpirit and the ſalt of amber are conſidered as inciſive, cordial, and antiſeptic; they are alſo adminiſtered as powerful diuretics. Oil of amber is applied both externally and internally for the ſame purpoſes as amber itſelf: it is adminiſtered in ſmaller dozes, on account of its acting with more energy. The ſuccinated balſam of ſulphur is given in dozes of a few drops in certain drinks, or mixed with other ſubſtances in pills, and is ſucceſsful in pituitous affections, or defluxions of the breaſt and kidneys, &c. A ſyrup, called *ſyrup of amber*, is made up of ſpirit of amber and opium, and is ſucceſsfully uſed as a calming, an anodyne, and an antiſpaſmodic medicine. *Eau de luce* is prepared by pouring a few drops of oil of amber into a phial full of cauſtic ammoniac, and ſhaking the mixture till it take a milk-white colour. It has been long uſed in fainting-fits as a powerful ſtimulant: it is put to the noſtrils, and it then ſtimulates the nerves; and, by the ſneezing which it excites, the fluids are again put into motion, and the patient reſtored.

The moſt beautiful pieces of amber are cut and poliſhed into veſſels, heads of canes, necklaces, bracelets, ſnuff-boxes, &c. But this ſpecies of toys is no longer valued among us, ſince diamonds and cut ſtones have

been known and brought into uſe. They are ſent, however, to Perſia and China, and to other foreign countries, where they are ſtill valued as the greateſt curioſities. Wallerius ſays, that the moſt tranſparent pieces may be uſed for microſcopes, burning-glaſſes, priſms, &c. It is affirmed, that the late King of Pruſſia was poſſeſſed of an amber burning-glaſs a foot in diameter; and that in the cabinet of the Duke of Tuſcany there is a column of amber ten feet high, and of a moſt beautiful luſtre. Two pieces of this bituminous ſubſtance may be joined together, by dipping them into a ſolution of potaſh, heating them, and applying them to each other.

CHAP.

CHAP. XXV.

Species II. *Of Aſphaltus.*

ASPHALTUS, or *bitumen of Judea*, called alſo *funeral gum*, *amber of Sodom*, *mountain-pitch*, *balm* of *mummies*, &c. is a black bituminous ſubſtance, ponderous, ſolid, and conſiderably brilliant. It breaks eaſily, and its fracture is vitreous. A thin plate of this bitumen appears red between the eye and the light. Aſphaltus, when cold, has no ſmell; when rubbed, it emits a faint ſmell. It is found on the waters of the lake Aſphaltites, or the Dead Sea, in Judea, near which ſtood the ancient cities of Sodom and Gomorrha. The inhabitants of the adjacent country, finding the ſmell of the bitumen, which gathers on the waters of that lake, troubleſome, and the bitumen itſelf a profitable article of commerce, collect and expoſe it to ſale. Lemery, in his Dictionary of Drugs, ſays, that aſphaltus ſweats like liquid pitch out of the earth covered by the Dead Sea; and riſing above the waters, is there condenſed by the heat of the ſun, and the action of a ſalt which abounds in thoſe waters. It is alſo found on many lakes in China.

The aſphaltus of commerce, M. Valmont de Bomare tells us, is obtained from the mines of Daunemore, and eſpecially in the principality of Neufchatel and Wallengin. According to that naturaliſt, it is of two colours, either blackiſh or greyiſh. But ſuch aſphaltus is far from being pure; it ſeems to be only earth hardened, and intermixed with bitumen which has penetrated through it.

Naturaliſts are divided concerning the origin of aſphaltus, as well as concerning the other bitumens. Some think it a mineral product, formed of an acid united in the interior parts of the earth, with ſome fat matter. Others think it a reſinous vegetable matter, that has been buried under grouſid, and altered by mineral acids. The moſt general and probable opinion is, that it has been produced in the ſame way as amber, and is actually nothing but amber altered by the action of ſubterraneous fire. The ground of this opinion is, that amber, when melted and deprived of a part of its oil, becomes black, dry, brittle, and in all reſpects like aſphaltus. But it can be finally eſtabliſhed only by a comparative analyſis of this reſidue of amber and aſphaltus. Aſphaltus has not yet been examined with ſuch exactneſs as will allow us to preſume on the analogy between them.

Aſphaltus, when expoſed to fire, becomes liquid, ſwells, and burns with a thick flame and ſmoke; the ſmell of which is ſtrong, acrid, and diſagreeable. By diſtillation, it affords a coloured oil, like brown petroleum, and an acid phlegm.

Aſphaltus is uſed by the Arabians and Indians in the

ſame

ſame way as pitch for coating their veſſels. It enters into the compoſition of the black varniſhes which we get from China, and of thoſe artificial fires which burn on water. The Egyptians uſed it in embalming dead bodies; but it was employed for that purpoſe only by the poor, who could not afford to purchaſe dearer antiſeptic matters. Wallerius aſſerts, that the merchants prepare a ſort of aſphaltus of thick pitch, or by mixing and melting pitch with aſphaltus from Judea. But the fraud may be detected by means of alcohol, which entirely diſſolves pitch, but produces no change on aſphaltus, only taking itſelf from it a pale yellow colour.

CHAP. XXVI.

Species III. *Of Jet.*

JET, in Latin *gagas*, called by Pliny *black amber*, by Strabo, &c. *pangetis*, is a black bituminous ſubſtance, compact, hard like ſome ſtones, brilliant and vitreous in its fracture, and ſuſceptible of a fine poliſh. After being rubbed for ſome time, it attracts light bodies, and, like amber, appears to be electric. It has no ſmell: when heated, it acquires a ſmell nearly the ſame with that of the bitumen of Judea.

Jet is found in France, in Provence, and in the county of Foix. There is alſo a quarry of it which is wrought at Beleſtat in the Pyrenees. It is found too in Sweden, in Germany, and in Ireland. The quarries of jet are in ſtrata; they likewiſe contain pyrites and pit-coal, and moſt of the other bitumens.

This bitumen, when expoſed to a ſtrong heat, becomes ſoft and melts; it burns with a fœtid odour. By diſtillation, it affords oil and an acid liquor.

Of

Of the ſeveral opinions which have been advanced concerning the formation of jet, the moſt probable is that which repreſents it as aſphaltus condenſed and hardened by length of time. It has been adopted by the learned Wallerius.

Jet is uſed for mourning toys. At Wirtemberg it is wrought into bracelets, buttons, boxes, &c.

CHAP.

CHAP. XXVII.

Species IV. *Of Pit-coal.*

THE name of *foſſil-coal, pit-coal, ſtone-coal, lithantrax*, &c. is given to a black bituminous matter, foliated, either gliſtering or dull, brittle, and inferior in conſiſtency and purity to the bitumens which we have been deſcribing.

This bitumen derives its name from its combuſtibility, and the uſe to which it is in many countries applied. It is found in the interior parts of the earth, under ſtones of various degrees of hardneſs, and under aluminous and pyritous ſchiſti. Theſe ſchiſti always bear impreſſions of vegetables belonging to the fern-tribe, which have been obſerved by Bernard de Juſſieu to be moſtly exotics. Pit-coal is ſometimes nearer to, ſometimes more remote from, the ſurface of the earth. Its diſpoſition is always in horizontal or inclined layers; oftener in inclined. The beds or ſtrata which it compoſes differ from each other in conſiſtency, colour, gravity, &c. Over this bitumen, ſtrata

of foſſil-ſhells and madrepores, varying in extent, are often obſerved; a circumſtance which has led ſome moderns, particularly M. Parmentier, to think that it has been formed in the ſea by the depoſition and alteration of the oily or fat matters of marine animals. Moſt naturaliſts think it the reſidue of wood depoſited in the ground, and altered by acids.

Quarries of foſſil-coal are wrought like mines of metal by digging into them pits and galleries, and hewing down the coal with a ſort of pick-axes. The colliers are often in danger of loſing their lives by the elaſtic fluids diſengaged. This mephitis, which they call *choak damp*, puts out their lights, and ſeems to be carbonic acid gas. There likewiſe gathers in theſe mines a kind of inflammable gas, the effects of which are very noxious, and which ſometimes produces very dangerous exploſions.

Foſſil-coal is very plentiful in nature. It is found in England, Scotland, Ireland, Hainault, the territory of Liege, Sweden, Bohemia, Saxony, &c. Several provinces of France afford great quantities, particularly Burgundy, the diſtrict of Lyons, Forez, Auvergne, Normandy, &c.

Foſſil-coal is diſtinguiſhed by its hardneſs, or friability into ſtone-coal or earth-coal. The manner of its burning, and the phænomena which it exhibits during combuſtion, afford the beſt characteriſtics for diſtinguiſhing it into different ſpecies. Wallerius arranges foſſil-coals, conſidered in this point of view, under three ſpecies. 1. The ſcaly coal, which remains black after combuſtion. 2. The compact foliated coal, which affords, after being burnt, a ſpongy matter like ſcoriæ. 3. Fibrous pit-

coal,

coal, reſembling wood, which is reduced to aſhes by combuſtion.

This bitumen, when heated in contact with a burning body and air, takes fire; the more ſlowly, and with the greater difficulty, the more ponderous and compact it is: when it has once taken fire, it diffuſes a lively laſting heat, and burns long before being conſumed. It may be quenched and burnt again, for a number of times ſucceſſively. The inflammable matter contained in it appears to be very denſe, and in a manner fixed in ſome other incombuſtible ſubſtance, which oppoſes its combuſtion. It exhales as it burns a peculiar odour; which, however, is no way ſulphureous, if the coal be very pure, and contain no pyritous matter. The combuſtion of this bitumen ſeems very analogous to that of organic matters, as it may be ſtopped and afterwards renewed. The moſt volatile part of the oily combuſtible matter contained in pit-coal is indeed burnt and diſſipated when it is firſt expoſed to the action of heat; and if, after the whole of that principle is diſſipated, the combuſtion be ſtopped, the bitumen retains only the moſt fixed and the leaſt inflammable part of its oil, in a truly carbonaceous ſtate, and combined with an earthy baſe. It is by a proceſs of this nature that the Engliſh prepare their *coaks*, which are nothing but pit-coals deprived by the action of fire of the fluid part of their oil.

We may eaſily obſerve what happens in this operation, by heating this bitumen in cloſe veſſels, and in a diſtillatory apparatus. It affords in this way an alkaline phlegm, concrete ammoniacal carbonate, and an oil which, as the diſtillation proceeds, takes a deeper colour,

and

LIBRARY OFT ROMBA

and becomes more ponderous. There passes at the same time a large quantity of an elastic inflammable fluid, which is commonly thought to be oil in vapours, but is properly hydrogenous gas, mixed with azotic gas, with carbonaceous matter dissolved in it, and with carbonic acid gas. There remains in the retort a scorified carbonaceous matter, which is still susceptible of combustion, and is the same with the English *coak*. Observing carefully the action of fire on pure pit-coal, we perceive the coal to be first softened, and in a manner half melted. Some species of pit-coal do not experience this fusion, or rather softening, from the action of calorir. These species would seem to contain less oil than those which soften in the fire: but the last are the most frequent, and the best. The distinction of the pit-coal into different kinds, is far from being so exact as it will be made hereafter. M. Faujas has thrown some new light on this subject, in a Dissertation, published by him a few months since, on pit-coal. But as this property might render it unsuitable for the melting of ores, it must be deprived of it before it be applied to that purpose. After taking from it the principle which renders it liable to soften, that is, the oil which it contains in great abundance, and thus reducing it to a state nearly the same with that of vegetable coal, it then becomes suitable for the fusion of ores. Let us not forget to observe, that the ammonaic which pit-coal affords in such considerable quantity, affords an argument in favour of that opinion which represents this bitumen as produced from animal matters; for, as we shall hereafter see, bodies belonging to the animal kingdom always afford this salt when distilled. This analysis is performed in the

great way in various places in England; and the ſeveral products are collected in a peculiar diſtillatory apparatus. The oil is uſed for pitch; the ammoniac is uſed in the compoſition of ammoniacal muriate; and the reſidue is a very good *couk*. M. Faujas de Saint Fond has imported this uſeful art into France; and the trials which he has made in the king's garden have ſucceeded very well in the ſmall way: We have as yet no eſtabliſhment for carrying it on in the great way *.

Pit-coal is highly uſeful in countries deſtitute of wood. It is uſed as a combuſtible matter; and the dangerous effects which have been aſcribed to it are quite imaginary. The ſulphureous vapour which it has been ſaid to diffuſe has no exiſtence; for chemiſts have univerſally found, by the moſt exact analyſis, that pure mineral coal contains not an atom of ſulphur. From this we ſee the ignorance and impoſture of ſome people who have pretended to give proceſſes for purifying coals of ſulphur. Another conſideration which ſhould induce us to make as much uſe as poſſible of coals in France is, that ſuch enormous quantities of charcoal are conſumed in the working of ores, that our wood is likely to fail one day or another; it is eſpecially in works of that kind we ſhould try the uſe of pit-coal, as the Engliſh have long done. It is already beginning to be uſed in various manufactories among us; and in the famous founderies of iron at Creuſot, near Montcenis in Burgundy, there is a great inſtance of its application to theſe purpoſes, highly worthy of imitation.

Purified

* The Engliſh reader will here recollect the patriotic exertions of the Earl of Dundonald to eſtabliſh works of this kind in Britain. H.

Purified pit-coal is nothing but that which has been deprived of its oil by the action of fire. This ſort of coal burns without ſmoke, without ſoftening, and without diffuſing any ſtrong ſmell; in a word, it is a true *coak;* and is, on account of theſe properties, preferred for fires in rooms.

Another inconvenience, beſide the copious dark ſmoke proceeding from it, which attends the burning of pit-coal, is, that the copious and rapid ſtream of air requiſite to maintain it in combuſtion, carries before it, and volatilizes, a part of the aſhes. But both theſe inconveniences may be in a great meaſure remedied by a judicious conſtruction of chimneys; ſo that the current of air, and whatever matters mix with it, may be entirely carried up, and diſcharged in the air, and no part of it returned and diſperſed through the room.

This combuſtible matter will in France be applied with moſt advantage for the ſervice of arts and manufactures of all kinds; in conſequence of which, wood may be greatly ſaved for kitchen and room fires, and for building.

CHAP.

CHAP. XXVIII.

Species V. *Of Petroleum.*

THE name of *petroleum*, or *oil of ſtone*, has been given to a liquid bitumenous ſubſtance which runs between ſtones upon beds of rocks, or in various places on the ſurface of the earth. This oil is of various degrees of levity, ſmell, conſiſtency, and inflammability. Authors take notice of a great many varieties of it. The lighteſt, the moſt tranſparent, and the moſt inflammable *petroleum*, they have diſtinguiſhed by the name of *naphtha*. *Petroleum*, properly ſo called, is a liquid bitumen, ſomewhat thick, and of a deep brown colour: mineral pitch, again, is a black bitumen, thick, ſcarce liquid, tenacious, and adheſive to the fingers: The following varieties have been deſcribed by Wallerius, and ſeveral other naturaliſts.

Varieties.

1. White naphtha.
2. Red naphtha.

Varieties.

3. Green or dark naphtha.
4. Petroleum mixed with earth.
5. Petroleum trickling through ſtones.
6. Petroleum ſwimming on waters.
7. Mineral pitch, or *maltha*.
8. Piſſaſphaltus. It is of a middle conſiſtency, between that of common petroleum and that of aſphaltus, or bitumen of Judea.

The ſeveral ſorts of naphtha are found in Italy, in the duchy of Modena, and on Mount Chiaro, about twelve leagues from Placentia. Kempfer, in his *Amœnitates Exoticæ*, relates, that great quantities of it are gathered in many places in Perſia. Petroleum runs in Sicily, and in many places of Italy; in France, at the village of Gabian, in Languedoc; in Alſace, at Neufchatel in Switzerland; in Scotland, &c. Piſſaſphaltus and mineral pitch were formerly obtained from Babylon, in the building of the walls of which they had been employed; from Raguſa in Greece, and from the pond of Samoſata, the capital of Comagena in Syria. It is at preſent obtained from the principality of Neufchatel and Wallengin, from the Well de la Page, a league from Clermont-Ferrand in Auvergne, and from various other places.

With regard to theſe ſeveral varieties, it is to be obſerved, that they ſeem to be all produced from one common origin, and to be but different modifications of the ſame ſubſtance. Moſt naturaliſts and chemiſts aſcribe the formation of petrolea to the decompoſition of ſolid bitumens by the action of ſubterraneous fires. Naphtha,

they obſerve, appears to be the light oil which is firſt diſengaged by fire: that which follows after it, having colour and conſiſtency, forms the ſeveral ſorts of petroleum: And, laſtly, petrolea, united with earthy ſubſtances, or altered by acids, acquire the characteriſtics of mineral pitch, or piſſaſphaltus. The phænomena of the diſtillation of amber favour this opinion: It affords actually a ſort of naphtha, and a petroleum too, of a higher or a lighter brown colour, according to the degree of heat employed, and the length of time ſpent in the operation. Laſtly, They obſerve, that nature often affords all the different ſorts of petroleum in the ſame place, from the lighteſt naphtha to mineral pitch. Such are the fluid bitumens from Mount Feſtin, in the duchy of Modena. Although this opinion be very probable, yet other authors think petroleum an oily mineral combination, formed by the ſulphuric acid with ſome fat matters. But even ſuch a combination muſt ſtill be allowed to originate from organic beings; as fat matters are always formed by thoſe beings.

The chemical properties of petroleum have not yet been examined. We know only, that naphtha is very volatile, and ſo combuſtible, that it takes fire when brought near any burning body; it even appears by its volatility to attract the flame. From brown petroleum there is obtained an acid phlegm, and an oil which at the firſt reſembles naphtha, but acquires a colour as the diſtillation proceeds. There remains in the retort a thick matter like piſſaſphaltus, which by greater activity of fire may be rendered dry and brittle like aſphaltus, and entirely reduced to a carbonaceous ſtate. Alkalis ſcarce act upon petroleum: the ſulphuric acid co-

lours

lours and thickens it; the nitric acid kindles it, in the ſame manner as eſſential oils: it eaſily diſſolves ſulphur; it is coloured by metallic oxides; and it combines with amber, and with the help of heat ſoftens and diſſolves a part of it.

The ſeveral kinds of petroleum are uſed for various purpoſes in the countries in which they abound. Kempfer tells us, they are uſed in Perſia, to give light, and burnt in lamps with wicks. They may alſo be uſed for common fires. Lehman ſays, that for this end the naphtha is poured on a few handfuls of earth, and kindled with paper; it takes fire, and burns with great activity, but diffuſes a ſmoke in great abundance, which ſticks to all bodies that come in its way, and has a very diſagreeable ſmell. Petroleum is likewiſe thought to make part of the Greek fire. Thick petroleum makes alſo a very ſolid and durable mortar. By the decoction of piſſaſphaltus with water, an oil is obtained, which is uſed for pitching veſſels.

Laſtly, Some phyſicians have deſcribed petroleum with ſucceſs in diſorders affecting the muſcles, palſy, weakneſs, &c. by rubbing the ſkin with it, or expoſing it to its ſmoke. Vanhelmont thought friction with petroleum, an excellent cure for frozen limbs, and recommends it as a good preſervative againſt the effects of cold.

PART THIRD.

The VEGETABLE KINGDOM.

CHAP. I.

Of the Structure of Vegetables.

VEGETABLES are organized beings, confined to the ſurface of the earth, without ſenſibility or power of motion. They are known by their appearance, and the conformation of their parts. They are diſtinguiſhed from minerals, by receiving their nouriſhment internally, and elaborating the juices to which they owe their growth. They diſplay to our obſervation phænomena which depend on their organization, and are called *functions*; the chief of theſe is that of reproducing themſelves by ſeeds, or *ova*, like animals.

Vegetables differ from one another, 1. In ſize; they are divided into trees, ſhrubs, herbs, moſſes, &c. 2. In

local

local ſituation; ſome grow in dry grounds, others thrive in a moiſt ſoil; ſome, again, in ſand, clay, water, on the ſurfaces of ſtones, or on other vegetables, &c. 3. In ſmell, taſte, colour, &c. 4. In duration; plants either live for a number of years, or only for one year, or are produced and die twice a-year, &c. 5. In the uſes to which they are applicable; they are uſed either as aliments, or as medicines. A great many of them are made uſe of in the arts, for dyeing, &c. others for adorning gardens, &c.

Vegetables, conſidered with reſpect to the external conformation of their parts, conſiſt of ſix parts or organs, deſtined each to a peculiar function: theſe parts are the root, the ſtem, the leaf, the flower, the fruit, and the ſeed. Theſe, again, differ in different plants, in form, contexture, bulk, number, colour, hardneſs, taſte, &c.

1. The root is concealed in the ground, in water, or in the bark of ſome other vegetable. It is either tuberous, or fibrous, or bulbous. Its direction is either perpendicular or horizontal. Both its form and conſiſtency are ſubject to great varieties. Botaniſts divide the roots of plants into many ſpecies; which diſtinctions they ſometimes make uſe of to determine the ſpecific characters of the plants themſelves.

2. The ſtem proceeds from the root, and ſupports the other parts of the plant. It is either ſolid or hollow, ligneous or herbaceous, round, ſquare, triangular, or with two very acute angles, &c. The ſtem conſiſts of wood and bark. The wood is diſtinguiſhed into wood properly ſo called, and ſap: the bark conſiſts of the epidermis, the veſicular part or pulp, and the cor-

tical ſtrata or inner rind. The ſtem divides into branches, the ſtructure of which is preciſely the ſame with its ſtructure. This part, too, is liable to ſuch diverſities as enable botaniſts to eſtabliſh upon it the diſtinctive characters of ſpecies, and ſtill oftener of varieties.

3. The leaves of vegetables are extremely various: A. in form; they are oval, round, linear, ſagittated, haſtate, oblong, elliptical, cuneiform, &c.: B. in their poſition on the ſtem; they are ſeſſile, petiolate, oppoſite, alternate, ſtellate, perfoliate, vaginal, &c.: C. in their margins; they are uniform, dentate, crenate, ſerrate, repand, undulated, laciniated, truncated: D. in ſimplicity or compoſition; compound leaves are formed by the inſertion of foliolæ, or ſmaller leaves; they are then either digitate or conjugate, with either an even or an odd number of leaves: E. in place or ſituation; they are radical, cauline, or floral: F. in colour, ſmell, taſte, conſiſtency, &c.; they ſeem deſigned to abſorb elaſtic fluids from the atmoſphere, and to pour others into it, according to circumſtances.

4. The flowers are thoſe parts which Nature has deſigned to contain the organs of generation, and to preſerve them from injury till the fecundation be accompliſhed; at which time they fall off. A flower conſiſts of two parts; the exterior, deſigned to cover and protect the interior; the uſe of which is to re-produce the plant. The former comprehends the calix and the corolla; the calix is exterior, and of a green colour.

Linnæus divides the calices of plants into ſeven ſpecies; namely, the perianthium, the ſpartha or ſheath, the huſk, the involucrum, the amentum or catkin, the calyptra

calyptra or veil, and the volva. The corolla is the coloured part, commonly called the *flower*: it is either a ſingle piece, and monopetalous; or conſiſting of ſeveral pieces, polypetalous. Tournefort's ſyſtem is founded on the corolla. The pieces of the corolla are called *petals*. The organs incloſed, and often entirely concealed in the corolla, are the ſtamina and piſtils or ſtyles. The ſtamina are the male or fecundating parts; and are almoſt always more numerous than the piſtils. They conſiſt of the filament and the anthera. The anthera, placed at the extremity of the filament, is a ſmall bag, containing fecundating powder. The piſtil ſtands in the middle of the ſtamina; it is ſometimes on another flower, or even on another plant: this circumſtance has cauſed ſome plants to be diſtinguiſhed into male and female. The piſtil conſiſts of three parts; the inferior part, or ovarium, which contains the embryo, and is called in Latin *germen;* the filament, which riſes out of the ovarium, or ſtyle; and its extremity, which is more or leſs dilated, and is called *ſtigma*. The ſexual ſyſtem of Linnæus is founded on the number, and the relative poſitions of the ſtamina, and the piſtils. M. de Juſſieu has formed a ſyſtem from the inſertion of the ſtamina, above or under the germen, &c.

5. Flowers are ſucceeded by fruits. Botaniſts diſtinguiſh fruits into ſeven ſpecies; the capſule; the ſiliqua; the legumen; the conſeptaculum, which becomes dry; fruits having kernels; fruits having pippins and berries, which remain ſucculent. The purpoſe of theſe organs is to incloſe the ſeeds, and to protect them from ſuffering by the action of external bodies.

6. The ſeeds of plants differ greatly in form, magnitude, appendices, &c. The ſeed contains the plumula, or ſmall plant, the radicula, and the cotyledons. There are two of theſe latter in moſt vegetables; yet many families of plants have but one cotyledon. This part is to the grain, what the yellow and white of an egg are to the embryo-bird; it contains a ſubſtance intended for nutriment to the young plant during the germination. Beſides, the cotyledons of many ſeeds contain fleſhy and farinaceous bodies, &c.

Vegetables, conſidered as to their internal ſtructure, contain five ſpecies of veſſels, or organs, which exiſt through all their parts, 1. The common veſſels which convey the ſap. Theſe are placed in the middle of plants and trees; they riſe perpendicularly, but bend laterally, ſo as to form ſmall vacancies between them. 2. The peculiar veſſels which ſecrete and convey the juices peculiar to each vegetable, oils, reſins, gums, &c. Theſe are placed under the bark; they are often dilated into cavities, or reſervoirs; they ſeem to be excretory ducts. 3. The tracheæ, through which the air that vegetables take in from the atmoſphere, circulates. When a young and green branch is broken, theſe may be obſerved, and known from their ſpiral form, reſembling a cork-ſcrew. They are often full of ſap. 4. The utricles, which are formed of ſmall bags, containing the pith, and frequently colouring matter. They are placed in the middle of the ſtem. 5. The veſicular tiſſue, exhibiting a ſeries of ſmall cells, leading horizontally from the pith, croſſing the ſap-veſſels, filling up the vacuities among them, and ſpreading over the epidermis, where they form

a ſoft covering like the ſkins of animals. The veſicular tiſſue of vegetables ſeems to correſpond to the cellular membrane of animals.

All parts of vegetables conſiſt of an aſſemblage of theſe five kinds of veſſels; which are, each of them, more or fewer in number, dilated, contracted, &c. On this diverſity, in point of number and diſpoſition, depend the differences in the form and texture of the roots, ſtems, leaves, &c. of plants.

Malphigi, Grew, and Duhamel, are the three naturaliſts who have ſtudied the anatomy of vegetables with the greateſt ſucceſs; and their works will be conſulted with the greateſt advantage, concerning the internal ſtructure of the ſeveral parts of vegetable bodies.

CHAP.

CHAP. II.

Of the Natural Philoſophy of Vegetables.

ALL theſe organs of vegetables, of which we have given the above brief account, are deſigned for the performance of the various motions called *functions*. Theſe functions are,

1. The motion of the fluids, which is a ſort of circulation.

2. The alterations or changes produced on thoſe fluids, which are effected in their ſecretion.

3. The growth of the vegetable, and the developement of its parts by nutrition.

4. The exhalation of the ſeveral fluids elaborated by the organs of vegetables, and the receiving of ſeveral principles from the atmoſphere by the ſame organs.

5. The action of air, and the employment of that fluid in the veſſels of vegetables.

6. The motion performed by ſome of their parts.

7. That ſort of ſenſibility by which they court the contact of bodies that may be uſeful to them, ſuch as light, &c.

8. Laſtly, The ſeveral phænomena, by which plants are generated, and ſpecies reproduced. Let us conſider each of theſe functions more particularly.

The principal fluid in vegetables, which is called the *ſap*, is contained in certain ducts, which are known by the name of *common veſſels*. Theſe veſſels, ſituated in the centre of the ſtem, and under the bark, extend from the root all the way to the leaves and flowers. The ſap which they convey is a colourleſs fluid, more or leſs inſipid in taſte, and intended, like the blood of animals, to be ſeparated into different juices, for the nouriſhment and ſuſtenance of the various organs. In ſpring it flows very copiouſly, cauſing the plant to diſplay leaves and flowers. By applying ligatures, and by all the phænomena of vegetation, it has been proved, we think in a ſatisfactory manner, that the ſap aſcends from the root through the ſtem and the branches. We are not ſo certain whether it be true, as ſome naturaliſts have thought, that it deſcends again towards the root. The exiſtence of thoſe valves, which ſome botaniſts have repreſented as belonging to the common veſſels of plants, has not been demonſtrated; not at leaſt unleſs we give the name to certain filaments or hairs with which Tournefort and Duhamel have obſerved their interior ſides to be lined. There is a vaſt difference between this irregular motion and the circulation of the fluids in animals.

The ſap being conveyed into the utricles, and thence into the proper veſſels, is there elaborated in a peculiar manner. By this elaboration it is wrought into different fluids,

fluids, ſaccharine, oily, mucilaginous, which are diſcharged by an organic excretion; and of which the evacuation ſeems to be an advantage to the vegetable, as it does not appear to ſuffer even from a conſiderable loſs of theſe matters. This alteration of the fluids, which may be diſtinctly obſerved as it takes place in ſeveral of the organs, in the nectarium, for inſtance, at the extremity of the piſtil, in the pulp of fruits, at the baſe of the calices, and of many of the leaves, is entirely effected by a function ſimilar to that which in animals bears the name of *ſecretion*. Guettard has carried this analogy ſo far as to deſcribe glands of various forms, at the baſes of the leaves of fruit-trees, and towards the inner extremity of the petals of certain flowers. This ſecretion ſeparates the odorous principle, the colouring matter, the combuſtible ſubſtance, &c.; but it differs from animal ſecretion, as animal ſecretion is entirely owing to the organization of the glands which elaborate the animal fluids: whereas in vegetables, the juices conveyed through the common veſſels, are in the proper veſſels more expoſed to the contact of air and light, and the action of heat; and their ſituation renders them liable to paſs, by the operation of theſe agents, through a proceſs of fermentation, by which only they can be altered.

The ſap in the cavities of the utricles and the veſicular tiſſue, becomes thick, and acquires more or leſs conſiſtency. In conſequence of this alteration, it adheres to the ſides of the fibres, and incorporates with them gradually, ſo as to increaſe their dimenſions. Such is the mechaniſm by which vegetables are nouriſhed and grow, and unfold their parts. It bears a great reſemblance to the

the nutrition of animals. The veſicular tiſſue of vegetables, and the cellular membrane of animals, are formed with a ſimilar ſtructure, and intended to ſerve ſimilar purpoſes. They paſs in the ſame manner through all the organs of the bodies to which they reſpectively belong; they eſtabliſh a direct communication among theſe organs; and both may be ſaid to be the ſeats of nutrition.

Philoſophical botaniſts have long been convinced, that plants exhale effluvia, from their ſurfaces, which are diffuſed through the air. The odorate ſpirit of leaves and flowers forms round vegetables, an atmoſphere which affects the ſenſes in a lively manner; and which, as has been obſerved with regard to the fraxinella, the contact of a burning body will ſometimes ſet on fire. This effluvia appears to be an inflammable gas of a peculiar nature. Mankind have alſo learned from fatal experience, that ſome vegetables exhale vapours, noxious to ſuch animals as approach them. The walnut, the yew, and many other trees, natives of warm climates, are of this kind.

M. Ingenhouſz has diſcovered by experiment, that the leaves of all plants, when expoſed to the ſun and to light, pour into the atmoſphere an inviſible fluid, which is vital air of the ſame qualities with that obtained from oxide of manganeſe, mercury, &c. But in the ſhade they no longer exert ſuch a property; inſtead of vital air, they give out carbonic acid gas, when deprived of the contact of light. This valuable diſcovery, which was firſt communicated to the world by Dr Prieſtley, ſhows vegetables to poſſeſs a property that was not before attributed to them, and to be capable of purifying

and

and renovating the air, by pouring into it a portion of that vivifying fluid which is conſtantly conſumed by combuſtion, reſpiration, &c. But if vegetables are continually diffuſing vaporous fluids through the atmoſphere, produced by the laſt proceſſes of vegetation; they likewiſe abſorb ſeveral of the principles of the atmoſphere. The experiments of Bonnet ſhow, that the under ſurface of the leaves abſorbs moiſture from the dew. Dr Prieſtley has proved, by his reſearches, that vegetables abſorb the gazeous reſidues of combuſtion and reſpiration; for vegetation is more ſpeedy and vigorous in air altered by theſe phænomena. Exhalation and inhalation are therefore much more conſiderable and important phænomena of the vegetable kingdom, than they were known to be before the modern diſcoveries. It even appears, that the water abſorbed by the under part of the leaves is decompoſed by their organs, its hydrogenous gas abſorbed, and its oxigene converted into the vital air which is diſengaged from the upper ſurfaces of the leaves. The rays of the ſun contribute greatly to this decompoſition; for it does not take place in the ſhade. The water being then not decompoſed, but abſorbed entire, renders the plants white, inſipid, ſoft, and in a word *æticlated*; and in ſuch caſes, much leſs colouring, combuſtible, or oily matter, is formed, than when the plant is expoſed to the action of light.

The gaſes abſorbed by vegetables are conveyed through all their organs by veſſels known under the name of *tracheæ*, which in their uſe and ſtructure bear a reſemblance to thoſe of inſects and worms. But the conveyance of this fluid is not the only purpoſe for which theſe tracheæ are intended. They are obſerved to be

filled

filled with ſap in the ſeaſon when that fluid flows in greateſt abundance; a circumſtance which diſtinguiſhes them widely from thoſe organs of reſpiration which belong to ſo great a number of animals, and are ſo eſſentially neceſſary. From the theory of reſpiration which we have laid down in the hiſtory of air, it is eaſy to explain why vegetables poſſeſs not free heat in a degree of temperature ſuperior to that of the atmoſphere.

Several parts of vegetables have, no doubt, an internal principle of motion. In ſome plants this motion is ſo conſiderable as to be obſervable by the eye. Such is the motion of the ſenſitive plant, of the ſtamina of the Indian fig, of pellitory, &c. This motion ſeems to correſpond to that function of animal organs which is called *irritability;* for it is effected by the action of a ſtimulus, and by peculiar organs, which are by ſome botaniſts compared to the muſcular fibres.

Can we deny plants to poſſeſs a ſort of ſenſibility, when we ſee them turn their leaves and flowers towards the ſun; when we obſerve, that, if encloſed in boxes of wood, with glaſs on one ſide, or perforated with an open hole, or ſimply thinner on that ſide than on the other, they conſtantly turn towards the tranſparent body, or the aperture through which light is permitted to enter, or the ſide which, being thinner, is nearer to that fluid than the other? Or, is this appearance of ſenſibility rather to be conſidered as an effect of the power of affinity, of the tendency of vegetables to combine with light? It has been fully proved, that, either by percuſſion or combination, this ſubſtance produces in plants the properties of colour, taſte, and combuſtibility; in the ſhade, even the talleſt plants are white, inſipid, aqueous, and

deſtitute

deſtitute of any inflammable principle: but, again, vegetables expoſed to the rays of the ſun, in the torrid climates of the ſouth, are very high coloured, contain bitter and reſinous parts, and are very combuſtible. However ſtrong this affinity be allowed to be, yet it is hard to imagine how it could excite ſuch a motion in the branches and leaves of vegetables. We muſt therefore grant them a peculiar ſenſation, a ſort of feeling very different indeed from that of animals, by which they are enabled to diſtinguiſh and prefer ſuch ſituations as are moſt expoſed to the light.

The methods which nature uſes for the reproduction of ſpecies of vegetables are ſtrongly analogous to thoſe by which the generations of animals are perpetuated. The greateſt number of the ſpecies of plants are propagated by ſexual coition. The labours of the celebrated Linnæus have diſcovered a ſtriking reſemblance between the organs deſigned for this purpoſe in theſe two claſſes of organic beings. The ſtamina of plants correſpond to the genital parts of male animals, and the piſtils conſiſt of three parts, which bear an equal reſemblance to the ſame organs of female animals. The embryo is developed by the action of the fecundating powder, without which a new individual could not be produced from it; agreeably to what is daily obſerved of birds. But beſides this analogy, which it would be needleſs to trace farther, as vegetables are of a much ſimpler ſtructure than animals, and their parts conſiſt all of the ſame organs, any of them is capable of producing a new individual ſimilar to that which it belonged. This is the reaſon of the reproduction of plants by means of ſcions or ſlips, as well

well as of the alteration of their fluids by grafting, whether natural or artificial. Here, therefore, is another analogy between vegetables and that claſs of animals which are reproduced by diviſion into pieces, as polypi, cruſtaceous inſects, certain worms, &c.

All theſe functions of vegetables, which bear ſo ſtriking an analogy to thoſe of animals, are liable to alterations, by which the vegetable is brought into a diſeaſed ſtate. Theſe diſeaſes to which plants are liable, depend commonly either on ſuperfluity or defect of ſap, as well as on the bad qualities which the ſap may happen to acquire; and they bear, therefore, no ſmall reſemblance to thoſe with which animals are affected. Their cauſes, ſymptoms, and cure, come under the general principles of medicine; and form a branch of agricultural knowledge, in which, it muſt be confeſſed, little progreſs has yet been made; but which may be greatly advanced by following the directions of ſome celebrated modern writers on the ſubject.

CHAP. III.

Of Juices and Extracts.

THE fluids contained in vegetables are of two kinds, the common and the proper juices. The firſt of theſe conſtitute the ſap, which is found in all plants. This fluid ſeems to perform the ſame functions in vegetable, which the blood does in animal bodies. It is contained in the common veſſels: It runs naturally from their ſurfaces; but may be extracted in greater abundance by inciſion. The ſap is not an aqueous fluid, but contains ſalts, extracts, and mucilages. When a certain quantity of it is wanted, in order to an examination of its properties, or for medical uſes, the plant is brayed in a mortar, and ſqueezed through a linen cloth: if the plant do not readily yield its juice, it is put into a preſs.

Succulent vegetables give out their juice by ſimple expreſſion. Thoſe whoſe juices are viſcid, or not very copious, muſt be treated with water to ſwell and dilute them; ſuch are borage and the dry aromatic plants.

This

This fluid, when extracted by the force of preſſure, is found to contain a portion of the ſolids of the vegetable, which were bruiſed with the peſtil: it muſt then be purified. Juices of plants are purified, 1. Simply by reſt, or by filtration, when they are very fluid: in this way, for inſtance, are the juices of purſlain and the houſe-leek purified. 2. By the white of eggs, which collects the impure parts by coagulation; it is uſed with borage, nettles, &c. 3. By the ſimple application of heat, which coagulates and precipitates the parenchyma: M. Baumé recommends this as the beſt way for purifying thoſe vegetable juices which contain volatile principles, ſuch as that of cochlearia, creſſes, &c. The phial containing the juice is immerſed in boiling water, care having been taken to cover it with a piece of paper perforated with a hole; when the juice becomes pure, it is taken out; it is then immerſed in cold water, and the juice filtrated. 4. By alcohol, which coagulates the feculent part. 5. By vegetable acids, which the London Pharmacopœia preſcribes for the juices of cruciform plants.

There are matters diſſolved in the juices of plants, which, when ſeparated from the aqueous vehicle, form what is called in pharmacy the *extract*. Theſe matters are diſtinguiſhed into three ſpecies, mucilaginous, ſaponaceous, and gum-reſinous extracts.

Thoſe are called *mucilaginous extracts* which diſſolve eaſily in water, are ſcarce ſoluble in alcohol, and undergo ſpirituous fermentation; ſuch is the rob of the gooſeberry, which is prepared by evaporating the juice.

Saponaceous extracts diſſolve in water, ar partly ſo-

luble in alcohol, and rather mould than paſs into a ſtate of ſpirituous fermentation. Such is the juice of borage when reduced to an extract. Theſe are extracts properly ſo called.

Gum-reſins are ſoluble both in water and in alcohol. They are inflammable, as containing a reſinous principle, and are not liable to ſuffer any alteration from air. The concentrated juice of wild cucumber, called *elaterium*, is of this ſort. Inciſions are made in the fruit of this plant; and the juice ſqueezed out, ſuffered to clarify of itſelf, and evaporated to dryneſs on a water-bath.

Theſe three different ſorts of extracts are prepared in the great way for commerce, by the evaporation of the juice of various plants. Of theſe, among others, are,

1. The juice of acacia; which is prepared in Egypt by pounding the fruit of that tree, preſſing out the juice, and evaporating it by the ſun: the juice of acacia, from Germany, is prepared from the juice of ſloes by a ſimilar proceſs.

2. That of hypociſtis, which is prepared like the above, from the fruits of this paraſitical plant.

3. Opium, a medicine of great importance, the nature of which ſhould be very well known. It is extracted from the white poppy in Perſia, &c. There flows out, by inciſions made in the green capſules of that plant, a white juice, which is dried into brown tears; this is the true opium. The opium which is commonly ſold, is prepared by firſt ſoaking the capſules in water, and then ſqueezing them; this juice is dried, and formed into flat circular cakes, covered with leaves, and mixed

mixed with a good deal of impurities. To purify it, it is diſſolved by the help of heat, with as ſmall a quantity of water as poſſible; the liquor is filtrated or ſtrained by ſtrong preſſure, and evaporated on a balneum mariæ. This is the extract of opium. This ſubſtance contains a ſaponaceous extract, a reſin, a ſolid eſſential oil, an odorous principle, which is poiſonous and narcacotic, an eſſential ſalt, and a glutinous matter. As the odorous, poiſonous, and narcotic principle, is often noxious, attempts have been made to obtain the extract of opium without that principle. M. Baumé, who has examined this medicine with much care, volatilized that principle, together with the eſſential oil, and in conſequence of that, ſeparated the reſin by digeſtion, for ſix months. Bucquet has diſcovered, that this extract may be obtained in ſuch a ſtate as to be ſedative, and not narcotic, by diſſolving opium in cold water, and evaporating the ſolution in a balneum mariæ. Lorry, who has made ſome very valuable experiments on this matter, has diſcovered, that fermented opium affords by diſtillation a ſedative water which has no poiſonous qualities, and has preſcribed it with great ſucceſs. He obſerves, that the odorous principle of this medicine cannot be deſtroyed by this proceſs.

To obtain the extracts of dry ligneous plants, we muſt employ maceration, infuſion, or decoction in water, according to the particular ſtate and nature of the matter, from which the extract is deſired; maceration is often ſufficient. Odorous plants can only be treated by infuſion. Decoction carries off too much of their ſubſtance, and ſeparates the reſinous part: it forms an highly concentrated thick fluid, which becomes turbid

by cooling. Infuſion will be ſufficient in any caſe. Such is the opinion of the greateſt chemiſts and the moſt celebrated phyſicians.

By water, various products can be extracted from ſeveral plants. Thus juniper-berries afford with water a mucilaginous extract; quinquina affords a ſaponaceous extract, which is obtained in ſmall tranſparent ſcales, of a ſaline appearance, if the ſolution be evaporated in broad flat veſſels; rhubarb affords in the ſame manner a gum-reſinous ſubſtance.

The chemical extract, properly ſo called, or the ſaponaceous extract, was thought to be a compound of oil with fixed vegetable alkali. It was juſtly obſerved, however, that the extracts prepared in pharmacy are far from being all of the ſame nature; they are mixed with mucilage, eſſential ſalt, ſaccharine juice, and reſin. For this reaſon, Rouelle, with a view to throw new light on this part of medical chemiſtry, has diſtinguiſhed them, as above mentioned, into three genera. But the pure extract, reckoned among the immediate principles of vegetables, is to be conſidered as a compound differing from the others, and poſſeſſed of peculiar properties. I have juſt diſcovered, that this principle is not a ſoap; that it poſſeſſes the property of abſorbing oxigene from the atmoſphere; of becoming inſoluble in water, and of aſſuming the characters of a concrete oil. Theſe are the properties by which I aſcertain the preſence of this ſubſtance, and diſtinguiſh it from all the other immediate principles of vegetables.

There are extracts prepared in the great way for commerce by water. Such are,

1. The juice of liquorice, which is yellow by the firſt infuſion, and black by a powerful decoction. The black juice is burnt, and actually contains coal. It is purified by melting it in water, filtering and evaporating the ſolution, which is rendered aromatic by the addition of eſſential oil, of anniſeed, cinnamon, &c.

2. The cachou, which is obtained in the Eaſt Indies, from an infuſion of the ſeed of a certain palm-tree, called the *areca*. This ſolution is evaporated, and the matter obtained is formed into broad cakes. The cachou is purified for medical purpoſes by ſolution in water and evaporation. It is ſeaſoned with aromatics like liquorice-juice.

Among the extracts which are prepared for medical purpoſes, Rouelle has taken particular notice of thoſe mixed with reſin, by the name of *extracto-reſinous*, or *reſino-extractive matter*.

Extracto-reſinous matter does not burn till after it be dried: it ſeems to contain more extract, properly ſo called, than reſin. *Reſino-extractive matter* burns much better than the former: it ſeems to contain a greater proportion of reſin than of the extractive matter. This diſtinction proves theſe two ſpecies to be nothing but mixtures of extract in various proportions with a reſinous principle. They are not, therefore, extracts properly ſo called; and the name can be with propriety applied only to the ſaponaceous matter; which is therefore the ſubſtance whoſe properties we ought to examine.

The pure extract differs from thoſe above mentioned. Taking all its properties together, we may conſider it

as a dry ſolid ſubſtance, of a brown red colour, tranſparent, not capable of burning by itſelf, but which exhales a good deal of ſmoke, and is found to contain more or leſs eſſential ſalt. Its taſte is almoſt always bitter, it affords by diſtillation an inſipid phlegm; expoſed to a moderate fire, the phlegm by degrees takes a colour, and becomes of an alkaline nature, which is obſerved of elaterium, the extract of borage, &c. The ammoniac of the product, is formed by the heat: there paſſes next a little empyreumatic oil; the coal is light, contains potaſh, and almoſt always neutral ſalts. The extract, when expoſed to the air, acquires a kind of moulding over its ſurface, and attracts moiſture; and the ſalts mixed with it, cryſtallize and ſeparate from the extractive part. They are often entirely altered and decompoſed on this occaſion. It diſſolves in water, and is then like a ſtrong infuſion. Acids decompoſe this ſolution like ſoaps. Metallic ſolutions likewiſe precipitate it; and the ſubſtances are, on this occaſion, mutually decompoſed. Theſe properties were thought ſufficient to make extract be looked upon as a kind of ſoap: they are moſtly owing, however, to the attraction of this ſubſtance for oxigene, and to its abſorption of this principle. Extract, therefore, properly ſo called, muſt henceforth be conſidered as an organic compound of hydrogene, carbone, and a little azote, poſſeſſing a ſtrong attraction for oxigene, which it abſorbs from every ſubſtance that contains it, and afterwards paſſes into an oily concrete ſtate.

Extracts are employed in medicine as aperitives, diſcuſſives, diuretics, ſtomachics, and almoſt always with great ſucceſs.

CHAP.

CHAP. IV.

Of the eſſential Salts of Vegetables; and of thoſe in particular which are analagous to Mineral Salts.

THE ſaline ſubſtances held in ſolution in the juices of plants, or in water in which they have been infuſed, are called their *eſſential ſalts*. They are extracted by ſuffering theſe fluids to cool, after they have been evaporated to the conſiſtency of a ſyrup. As theſe ſalts are impregnated with extracts and fat matters, they need to be purified with lime and the white of eggs. When the ſalts are acid, lime muſt not be uſed, as it would neutralize them, but pure white clay in powder. After this firſt extraction, they are ſtill very impure. They are diſſolved in diſtilled water, and repeatedly cryſtallized till they become white. This proceſs can be employed only on thoſe eſſential ſalts of vegetables which are cryſtallizable; but there have been ſome vegetable ſalts diſcovered which are not cryſtallizable, and which, on account of their mixture or combination with other principles, cannot be extracted by ſuch a ſimple proceſs. In giving an account of the ſalts contained

in

vegetables, or at leaſt obtained from them, we ſhall diſtinguiſh them into the following ſix genera.

The firſt genus comprehends all ſuch vegetable ſalts as are analogous to thoſe with which we are acquainted in the mineral kingdom.

The ſecond conſiſts of the pure acid ſalts of plants.

In the third we ſhall rank acid ſalts combined with a certain quantity of potaſh, under the generic name of *acidulæ*.

To the fourth genus we may refer ſuch as are formed by the action of the nitric acid on ſome vegetable matter.

The fifth may contain ſuch as owe their formation to heat.

Laſtly, Under the ſixth we include vegetable acids produced by a particular fermentation.

Firſt Genus of Vegetable Salts. Salts analogous to thoſe of the Mineral Kingdom.

The firſt genus of the eſſential ſalts of vegetables comprehends neutral ſalts extracted from their juices by evaporation, which are analogous to thoſe of the mineral kingdom. The principal ſpecies of theſe ſalts are, 1. Fixed alkalis in combination with carbonic acid, which are obtained from almoſt all plants, by macerating them in acids, as has been ſhown by Margraff and Rouelle the younger: potaſh is moſt commonly obtained; ſoda exiſts in ſome marine plants. 2. Sulphate of potaſh, in millefoil, in old borage, in aſtringent and aromatic plants, in ſpurge flax, and in the mark of olives. 3. Sulphate of ſoda, from the marſh, and from rotten

rotten wood. 4. Nitre, from borage, turnſole, tobacco, &c. 5. Muriate of potaſh, and muriate of ſoda, from marine plants. 6. Sulphate of lime, diſcovered by Model in rhubarb. The exiſtence of the laſt ſalt is doubtful; for Scheele ſuſpects that what Model took for ſulphate of lime was only calcareous oxalate.

By an accurate analyſis of a greater number of plants, many other ſalts might no doubt be found in vegetables, reſembling mineral ſalts. It was alſo thought that ammoniacal carbonate exiſted ready formed in ſome cruciform plants; becauſe thoſe plants, when diſtilled, afforded, by the firſt impreſſion of the heat, a phlegm, in which there was a little of this ſalt diſſolved. The ancient chemiſts, on this account, called thoſe plants *animal plants*. But Rouelle the younger has ſhown, that the ſalt is not ready formed in the plant, but is produced in conſequence of the re-action of the principles of the plant occaſioned by heat. M. Baumé has repreſented this volatile principle of cruciform plants, as being nothing but ſulphur. The ammonaic obtained from thoſe plants has been fully proved by M. Berthollet, to proceed from the combination of the hydrogenous part of the oil with the azote contained in the vegetable.

Naturaliſts have been of different opinions concerning the mineral ſalts found in plants. Some think the ſalts to be conveyed from the earth into the vegetable by water, without alteration. Others think them to be formed by the act of vegetation. One thing certain is, that two very different plants, ſuch as borage and milleſoil, growing on the ſame ſoil, afford each its peculiar acid; borage, nitre, and milleſoil, ſulphate of potaſh. This

doubtful

doubtful queſtion might be determined by a ſingle experiment; of which much has been ſaid, but which has never been performed with ſufficient exactneſs. The experiment is, to raiſe, from a previouſly lixiviated earth, plants affording a kind of ſalt, like nitre, and to water them with water impregnated with muriate of ſoda, or ſome other ſalt. If they ſhould be ſtill found to afford nitre, and not muriate of ſoda, it might be inferred, that ſalt does not paſs from the earth into the plant unaltered, but that the proper ſalt is formed in the plant by the functions of vegetation. Whatever may be the reſult of this experiment, it will be proved, that a number of the ſalts which we examined in the mineral kingdom are immediately formed in vegetables.

CHAP.

CHAP. V.

Of the ſecond Genus of Eſſential Salts, or of the Pure Acids of Vegetables.

IN the ſecond genus of eſſential vegetable ſalts, we rank thoſe acids which are entirely formed in plants, and are extracted from them pure by very ſimple proceſſes. There are five acids of this genus, the citric, the gallic, the malic, and the benzoic.

§ 1. *Of the Citric Acid.*

WE give the name of *citric acid* to the pure acid which Scheele obtained from lemon-juice.

Chemiſts formerly, without attending to the peculiar characteriſtic of this acid juice, compared it to that of tartar; and at that period all vegetable acids were thought to be of the ſame nature. Attempts have been made to concentrate and purify the acid juice of the lemon

mon and the orange, in order to preſerve them for long voyages. The juice of the former of theſe fruits has ſuch an acid taſte, and produces ſuch an effectual alteration on blue colours, that there can be no doubt entertained concerning its nature. M. de Morveau has found the ſpecific gravity of this juice to be to that of diſtilled water as 1,860 to 1.

When this juice is kept for ſome time, it acquires a diſagreeable taſte, and is covered over with a mouldineſs: this alteration is owing to its containing a conſiderable proportion of mucilage, of which chemiſts have endeavoured to purify it. Before means were found out by which that might be accompliſhed, it was preſerved in glaſs bottles, and covered with oil. Some people propoſed to put ſand into the veſſels; others added a mineral acid; either of theſe proceſſes altered the nature of the juice. The firſt was ſuperior to the others; but even with it, the juice, in the ſpace of a few days, contracted a tart, oily, and diſagreeable taſte. M. Georgius, in the year 1774, publiſhed, among the Acts of the Academy of Stockholm, a proceſs for concentrating the acid juice of citrons, and rendering it unalterable. He directs this juice to be kept for ſome time in the cellar, in inverted bottles, in order to ſeparate from it a part of the mucilage, and to expoſe it to a cold three or four degrees under o in Reamur's thermometer; the aqueous part freezes, carrying with it, as would appear, a portion of the mucilaginous matter: care muſt be taken, as the ice forms, to ſeparate the liquid from it; and the congelation muſt be carried on till the ice become acid. M. Georgius has found, that when the juice is reduced to an eighth part of its bulk, and is eight times as ſtrong as before, a

drachm of citron juice, concentrated by congelation, will ſaturate thirty-ſix grains of potaſh, which would require to ſaturate it an ounce of the ſame juice before concentration. This acid, thus concentrated, may be employed for many œconomical purpoſes. Dry lemonade is prepared by mixing it with ſugar refined and reduced to powder, in the proportion of one part to ſix.

Citron, or lemon-juice, if expoſed ſoon after its preparation to an atmoſphere above the temperature of 15° of Reamur, depoſites a white ſemi-tranſparent, mucilaginous matter, of a gelatinous conſiſtency; this juice, when decanted and filtered, becomes leſs liable to alteration than before. The mucilaginous matter, when dried, does not diſſolve in boiling water: when treated with the acid of nitre, it affords gas azote, and is converted into oxalic acid: this is not a gummy mucilage, but bears an analogy to the vegetable gluten, of which we ſpoke in the article *farina*.

M. Dubuiſſon has preſerved citron-juice by a proceſs directly oppoſite to that of M. Georgius. On evaporating this juice by a moderate heat long continued, the mucilage becomes thick, and ſeparates in the form of a cruſt and glutinous flakes; the acid liquid is concentrated, and may be long kept in well ſtopped bottles, without being liable to alteration. M. Dubuiſſon has obſerved, that the contact of the air which remains between the ſtopper and the ſurface of this acid liquor concentrated by evaporation, is ſufficient to ſeparate in a few weeks flakes of a white ſubſtance, which he thinks to be glutinous, and which collecting on the ſurface, form there an elaſtic conſiſtent body. The acid is not ſenſibly altered during this ſeparation.

Theſe

Theſe are the ſeveral proceſſes which were propoſed and uſed, before Scheele's time, for purifying and preſerving citron-juice. From them it appears, indeed, that this acid had engaged the attention of chemiſts; but it was prepared only for the purpoſes of pharmacy; and ſo fully was every one perſuaded that its nature was the ſame with that of the acid of tartar, that no doubt was ever ſuggeſted of that being the caſe. Stahl had aſſerted, that lemon-juice, when ſaturated with the lobſter-ſtone, or with chalk, acquired the nature of vinegar. Several chemiſts had attempted to combine it with alkalis, without obtaining permanent cryſtals from the combination, on account no doubt of the mucilage ſo plentifully mixed with it. M. de Morveau, however, informs us, that by ſaturating lemon-juice with carbonate of potaſh, expoſing the ſolution to the air, and filtering it ſeveral times, he obtained from it a ſalt cryſtallized in ſmall opaque grains not liable to deliquiate.

Scheele, in Crell's Journal, in the year 1784, gave a proceſs for obtaining the acid of lemon very pure, ſeparated from the mucilage and the extractive matter by which it is altered in the juice as preſſed from the fruit, and in a concrete form. He firſt employed alcohol to ſeparate the mucilage by coagulation, and did not ſucceed; the liquor, when inſpiſſated, filtered, and evaporated, afforded no cryſtals. He tried the proceſs which he had ſeveral years before diſcovered for purifying the acid of tartar, and obtained the acid of lemon, pure and concreted. The proceſs is as follows: Saturate boiling lemon-juice with pulverized chalk. The acid forms with the lime a ſalt that is ſcarce ſoluble, and the mucilaginous and extractive

ſubſtances

ſubſtances remain diſſolved in the ſupernatant liquor; the precipitate is to be waſhed with lukewarm water, till it ceaſe to deepen in colour; it diſſolves nearly as well as ſulphate of lime: it is then treated with as much ſulphuric acid as is requiſite to ſaturate the chalk, diluted in ten parts of water; and the mixture is now boiled for a few minutes. Afterwards it muſt be cooled and filtered; the ſulphate of lime remains on the filter; and the liquor affords, by evaporation, a concrete cryſtallized acid. In this operation, it is better, as Scheele has remarked, to uſe an exceſs of ſulphuric acid, than to leave a little lime not ſaturated: as this would prevent the citric acid from cryſtallizing; whereas, when there is an exceſs of ſulphuric acid, it remains in the mother-water.

The citric acid thus prepared is very pure and highly concentrated: its taſte is ſtrongly acid; it reddens all blue vegetable colours that are ſuſceptible of ſuch a change. Fire decompoſes it, converting it into acidulous phlegm, gazeous carbonic acid, and carbonated hydrogenous gas: there remains in the retort a little coal: air effects no alteration on its cryſtals. It diſſolves eaſily enough in water. The ſolution is decompoſed by an actual putrefaction, which indeed takes place but very ſlowly. With earths and alkalis, it forms citrates of aluminous earth, barytes, magneſia, lime, potaſh, ſoda, and ammoniac; the properties of which have not yet been examined, though they are known to differ from all other neutral ſalts. The nitric acid does not convert this, like ſeveral other vegetable acids, into oxalic acid: this appears indeed to be one of the moſt powerful vegetable acids. It acts with the help of

water on various metallic ſubſtances, chiefly on zinc, iron, copper, &c.

Bergman has repreſented its affinities in the following order; lime, barytes, magneſia, potaſh, ſoda, ammoniac. M. de Breſſey of Dijon has an account of its affinities ſomewhat different from this. According to him, barytes holds the firſt place, lime the ſecond, and magneſia the third; the alkalis follow after theſe. It appears from the reſearches of both, that this acid prefers the three alkaline earths to the alkalis themſelves.

The uſes of the acid of lemon are various. With water and ſugar, it compoſes a very pleaſant drink, known by the name of *lemonade*. It is uſed in medicine as cooling, temperating, antiſeptic, antiſcorbutic, diuretic; it is eſpecially efficacious in correcting the acridity of the bile. It is ſometimes applied as a gentle eſcharotic to ſcorbutic ulcers, eruptions of the itch, and ſpots on the ſkin. When concentrated by the proceſs of M. Georgius, or that of M. Dubuiſſon, it may be put up for long voyages by ſea; and it is found of great utility on ſuch occaſions.

§ II. *Of the Gallic Acid.*

WE give the name of *gallic acid* to that which is extracted from the nut-gall, which grows on oaks in conſequence of the puncture of an inſect. This acid is generally found, either in a greater or a ſmaller quantity, in all four or aſtringent vegetable ſubſtances: Such are oak, aſh, willow, and the barks of theſe trees, quinquina,

ſimarouba, pomegranate, ſumac, tormentillo, the cypreſs-nut, the ſtalk and leaves of the marſh iris, of the ſtrawberry ſhrub, of the water-lily, &c.

Chemiſts formerly diſtinguiſhed this matter by the name of the *aſtringent principle:* and all that they knew of it was, that it poſſeſſed excluſively the property by which its character was very diſtinctly marked, of producing black precipitates in ſolutions of iron in acids, and thus making ink. Meſſrs Macquer, Monnet, Lewis, Cartheuſer, and Goanetti, ſought to determine by experiments, in what manner this principle acts upon the metal. M. Monnet remarked, that nut-gall and aſtringent vegetable juices acted immediately on iron, and gave it a black colour. M. Gioanneti obſerved, that the atramentarious precipitate, or feculum, was not ſubject to the attraction of the magnet, and that iron therefore did not exiſt in the precipitate in a metallic ſtate, as had been before thought. Theſe obſervations might lead to the concluſion, that the aſtringent principle of nut-gall muſt be an acid, or at leaſt performed the part of an acid in chemical operations. The Academicians of Dijon were, however, the firſt after theſe writers who diſtinguiſhed, in their experiments, the aſtringent principle to be an acid. Theſe philoſophers have ſhown, 1. That the products of diſtilled nut-gall become black with the ſolution of ſulphate of iron. 2. That an ounce of this ſubſtance communicates to cold water a tincture, from which 3½ drachms of extract are obtained by evaporation. 3. That this infuſion reddens turnſol and blue paper. 4. That the ſame principle is ſoluble in oils, alcohol, and æther. 5. That acids diſſolve without altering it, and without depriving it of the property of

producing a black precipitate of iron. 6. That its ſolution in water precipitates alkaline ſulphures. 7. That it entirely decompoſes all ſolutions of metals, and communicates a colour to the oxides by combining with them. 8. Laſtly, That it directly diſſolves iron, and precipitates ſilver and gold, after ſeparating them from their ſolvents.

Such are the important facts concerning this ſubſtance, which have been communicated to the world by the Academicians of Dijon. Several of them had indeed been before obſerved by different chemiſts, but none had before aſcertained the acidity of the principle.

Since they communicated theſe obſervations to the world, Scheele has not only obſerved, that all four, aſtringent plants exhibit marks of acidity, but has diſcovered and deſcribed a proceſs for obtaining this vegetable acid pure and cryſtallized.

Upon a pound of nut-gall in powder, pour ſix pounds of diſtilled water; leave this mixture to macerate for the ſpace of fifteen days, in the temperature of from 16 to 20 degrees; then filtrate the liquor, and put it in a ſtone pot, or a large capſule of glaſs; ſuffer it to evaporate ſlowly in the air; a mouldineſs, and a thick and ſeemingly glutinous pellicle is then formed upon it: mucilaginous flakes are firſt precipitated in great abundance; the ſolution has no longer a very aſtringent taſte, but is more ſenſibly acid than before. After it has been two or three months expoſed to the air, there is obſerved on the ſides of the veſſels, and adhering to them, a brown plate, covered with granulated cryſtals, ſparkling, and of a yellowiſh grey colour: the ſame

cryſtals

cryſtals exiſt likewiſe in great abundance on the under ſide of the thick pellicle which covers the liquor: the liquor muſt now be decanted off; and hot alcohol is poured on the flaky ſediment, the pellicle, and the cryſtalline cruſt: this ſolvent takes up all the cryſtallized ſalt, but affects not the mucilage. This ſpirituous ſolution is then evaporated, and the gallic acid is obtained from it pure, in ſmall granulated cryſtals, of a grey colour, inclining a little to yellow, and brilliant.

The gallic acid thus purified has a taſte ſomewhat ſour and aſtringent. It produces in ſolutions of ſulphate, and of other ſalts, of iron, a very fine and brilliant black precipitate: it gives a high red colour to the tincture of turnſol; when heated in contact with air, it ſwells and kindles, diffuſing an agreeable enough ſmell, and leaves a coal, the incineration of which is very difficult: when diſtilled by a moderate fire, a part of it is diſſolved in the water of its cryſtals, and aſcends in that ſtate; another part is ſublimed, without being decompoſed in ſmall ſilky cryſtals; a ſtrong fire ſeparates from it ſome drops of oil, carbonic acid gas, and carbonated hydrogenous gas. Nut-gall, when diſtilled entire, affords a ſmall portion of concrete ſalt, reſembling the ſublimated gallic acid.

The gallic acid requires 24 parts of cold water to diſſolve it; of boiling water only three parts. Repeated ſolution and cryſtallization do not whiten it in a ſenſible manner. Alcohol diſſolves it much more efficaciouſly: four parts of this liquid, when cold, are ſufficient to diſſolve one of gallic acid; when boiling, it diſſolves a quantity of the acid equal to itſelf in weight.

This acid diſengages the carbonic acid from earthy and alkaline baſes, when its action is aſſiſted by heat.

With barytes, magneſia, and lime, it forms ſalts ſoluble in water, and eſpecially when there is an exceſs of the baſe. Potaſh, ſoda, and ammoniac, combine very readily with it, forming *gallates*, the properties of which are hitherto unknown. The nitric converts the gallic into oxalic acid.

The gallic acid precipitates gold in a brown powder, and cauſes a part of the metal to appear on the ſurface of its ſolution in a brilliant metallic pellicle. In the ſolution of ſilver it produces a brown precipitate; and ſoon after the precipitation, a plate of reduced ſilver appears on the ſurface of the liquor. From mercury it produces an orange yellow precipitate; from copper a brown precipitate; from iron a beautiful gliſtering black precipitate; from biſmuth a citron yellow precipitate. Solutions of platina, zinc, tin, cobalt, and manganeſe, ſuffer no alteration from this acid.

Such are the properties which Scheele allows to the gallic acid prepared by his proceſs. They are ſufficient to entitle it to the character of a peculiar acid, diſtinct from all others. Its intimate nature, and the proportion of its principles, have not yet been aſcertained. M. de Morveau obtained from it a reſin which he thinks to be the acidifiable baſe; by the union of which with oxigene the acid is formed.

The uſe of nut-gall for dyeing black is well enough known: we ſhall only add to what we have already ſaid of it in the article of iron, that when the pure gallic

lic acid is uſed in the preparation of ink, the ink is very beautiful, and very black, and remains long unaltered.

§ III. *Of the Malic Acid, or the Acid of Apples.*

WE give the name of *malic acid* to a peculiar vegetable acid which Scheele extracted from the juice of various fruits, and of which he found apples to contain a conſiderable quantity.

This acid is obtained by ſqueezing the juice from four apples, ſaturating it with potaſh, and mixing the liquor with a ſolution of acetite, or ſugar of lead. A double decompoſition is thus effected; the acetous acid combines with the potaſh, and the malic with the oxide of lead; the malate of lead is precipitated; that precipitate is waſhed; and, on its being treated with ſulphuric acid, ſulphate of lead is produced, and the malic acid ſwims above. A ſufficient quantity of ſulphuric acid muſt be poured in to diſſolve all the malate of lead; which, when it takes place, will be known from the taſte of the ſupernatant liquor.

The following are the properties of this acid. It cannot be obtained in a concrete form; with the three alkalis, it forms deliqueſcent neutral ſalts; with lime, it produces a ſalt that affords ſmall irregular cryſtals, ſoluble in boiling water, in vinegar, and in the malic acid itſelf; with aluminous earth, a ſalt that is ſcarce ſoluble; with magneſia, a deliquieſcent ſalt. It diſſolves iron, and the ſolution is brown, and not ſuſceptible of cryſtallization; it diſſolves zinc readily, and produces with it

a ſalt in very beautiful cryſtals: the nitric acid changes it into oxalic acid; it precipitates nitrate of mercury, lead, ſilver, and gold, in a metallic ſtate: calcareous malate decompoſes ammoniacal citrate, forming, in conſequence of the decompoſition calcareous citrate, not ſoluble in boiling water or in vegetable acids. The ſolution of calcareous malate in water is precipitated by alcohol; laſtly, The malic acid is ſpeedily deſtroyed by fire, which changes it into carbonic acid: the carbonic acid, thus formed, ſaturates in part the baſes of the malates decompoſed by heat. Such are the properties which form the peculiar character of this acid.

Scheele found it almoſt pure, or mixed with a little citric acid, in the juice of apples, of the barberry, of alder twigs, of the ſloe-thorn, of the ſorb-tree, and of the plum-tree; in gooſeberries, cherries, ſtrawberries, raſpberries, &c. Laſtly, He obtained it from ſugar by the nitric acid; and M. de Morveau remarks, that the malic acid ſhows itſelf in this caſe before the oxalic.

When four fruits contain both citric and malic acid, the following is Scheele's proceſs for ſeparating them, in order to obtain the latter pure. The juice of gooſeberries ſaturated with chalk, affords calcerous citrate, which, being inſoluble, is precipitated; the ſupernatant liquor holds in ſolution the calcareous malate, which is ſeparated by alcohol; but as it is ſtill in union with a mucilage, Scheele has had recourſe to another means for obtaining it pure. He evaporated the juice of gooſeberries to the conſiſtency of ſyrup; upon this ſyrup he poured alcohol, which diſſolved the acids without affecting the mucilage; he then filtrated the ſolution to ſeparate the mucilage; after the filtration of the liquor, he

evaporated

he evaporated the alcohol; the acids he ſaturated with chalk. The citric acid uniting with the chalk, was of conſequence depoſited in calcareous citrate; and the calcareous malate remained in ſolution. A new addition of alcohol precipitated it from the liquor; and Scheele then obtained the malic acid by diſſolving this ſalt in water, precipitating the ſolution by acetite of lead, and decompoſing the malate of lead by the ſulphuric acid; the malic acid was then found ſeparate in the ſupernatant liquor.

§ IV. *Of the Benzoic Acid, or the Acid of Benzoin.*

SINCE the days of Blaiſe de Vigenere, who wrote in the beginning of the laſt century, benzoin has been known to afford, by diſtillation, an acid ſalt cryſtallized in ſtrong ſmelling needles, of an acrid taſte, which in pharmacy are called *flowers of benzoin.* Chemiſts formerly thought this to be a particular modification of a mineral acid; but its diſtinctive properties are now ſo well known, that we can no longer doubt of its being a peculiar vegetable acid.

This acid is found to exiſt in benzoin, balm of Peru and Tolu, ſtorax, liquidambar, and vanilla, around which it is cryſtallized. Scheele has found it likewiſe in the ſugar of milk and the extract of urine. It will be ſhown under the article of *benzoin*, that the ſimple proceſs which was formely employed to obtain it, conſiſted in ſublimation by a moderate fire. Geoffroy diſcovered, in the year 1738, that it might be extracted by water, and that the ſaline ſubſtance was fully formed as it exiſted in benzoin; by the ſame proceſs, I extracted it from Peruvian

Peruvian balm, ſtorax, and the huſks of vanilla. But this proceſs affords only a ſmall quantity; for the reſin of benzoin, not mixing with the water, covers and preſerves a great part of the acid ſalt.

Scheele, in the year 1776, gave, in the Memoirs of Stockholm, ſome important obſervations on the benzoic acid: from ninety-ſix parts of benzoin he obtained, by ſublimation, between nine and ten parts of this ſublimated ſalt which was very far from what Spielman aſſerted that he obtained,—namely, a fourth part of the benzoin ſubmitted to diſtillation: it appears that the chemiſt of Straſburg had taken acid of benzoin mixed with empyreumatic oil for pure acid. Scheele, having reduced benzoin to powder and mixed it with chalk, boiled upon it a quantity of water, and then filtered the liquor, which afforded no ſalt by cooling: ſulphuric acid, poured into this liquor, ſeparated the benzoic acid in powder, and ſhowed that acid to have been united with a baſe of chalk, with which it formed a neutral ſalt ſoluble in water: the quantity of concrete acid, however, precipitated by this proceſs, was not more conſiderable than that which is obtained by ſimple lixiviation. Scheele thought that a greater quantity might be obtained by employing a matter capable of acting on the reſin, and facilitating the ſeparation of the ſalt. Potaſh did not ſerve his purpoſe; the reſin again collected on the ſurface of the liquor in a thick tenacious oil, on which account he could not expect the acid to be entirely ſeparated. With quicklime he was more ſucceſsful. According to him it is to be applied in the following manner: Take four ounces of quicklime; ſlake it with twelve ounces of water; add eight pounds more when the ebullition ceaſes;

mix

mix ſix ounces of this water with a pound of benzoin in powder; theſe ſubſtances need to be well ſtirred, in order that they may mix properly; pour in by degrees the remaining part of the lime-water; when the lime-water is thus gradually poured in, it hinders the benzoin from collecting into a maſs: this liquor muſt next be heated for half an hour by a moderate fire, and conſtantly ſtirred: it is then taken off the fire, and ſuffered to ſettle for ſeveral hours together: the clarified liquor is now decanted off; eight pounds of water are poured upon the reſidue; it is boiled for half an hour, and then mixed with the clarified liquor before poured off from it; the operation is finiſhed by putting the reſidue upon a filter, and pouring hot water upon it. Theſe lixivia are next reduced all to two pounds by evaporation; a little reſin is ſeparated: when the evaporated liquor is cooled, a quantity of muriatic acid is dropped upon it, till it ceaſe to produce a precipitate, and the liquor take a diſcernible acid taſte: the ſalt of benzoin is then precipitated in powder. It is to be edulcorated on the filter; when it is wanted in cryſtals, it is diſſolved in five or ſix times its weight of boiling water; it is then filtrated through a cloth, and the ſolution ſlowly cooled; the ſalt is depoſited in oblong compreſſed priſms. In this proceſs the lime abſorbs the benzoic acid, and forms with it calcareous benzoate, which is very ſoluble; and the reſin is ſeparated from that ſalt, which has but very little affinity with it. The muriatic acid which attracts lime with more force than the benzoic acid, ſeizes that earth, and ſeparates the vegetable acid. The liquor, when reduced to two pounds by evaporation, is no longer ſufficient to maintain the acid in ſolution, and

it —

it is therefore almoſt all depoſited. Calcareous benzoate has not the ſmell of benzoin; but as ſoon as the benzoin is ſeparated by the muriatic acid, it takes that lively ſmell which is peculiar to this balſamic ſubſtance. By this proceſs Scheele obtained twelve or fourteen drachms of benzioc acid from the pound of benzion; whereas ſublimation affords only nine or ten. He farther informs us, that the purification of this ſalt by hot water and by cryſtallization, cauſes a great quantity of it to be loſt, and is by no means neceſſary to prepare it for pharmaceutical purpoſes. In fact, this ſalt, when properly cryſtallized, is very difficult to be reduced to powder; and the deſign of the purification is to ſeparate only about two grains of reſin from the pound of benzoin. Laſtly, He remarks, that the filtration of this acid, diſſolved in water, can be effected only through a linen cloth. The ſalt being ſeparated quickly, as the liquor cools, ſtops up the pores of paper, ſo that the filtration cannot take place.

Since theſe experiments of Scheele's were made known to the world, M. Lichtenſtein has publiſhed in Germany ſome obſervations on the benzoic acid; in which he aſſerts, that ſublimation affords more of this acid than the proceſs by lime-water; but I agree with Scheele and Morveau, in thinking that this can be ſaid only of the purified acid.

The purified benzoic acid has a taſte ſomewhat ſour, pungent, hot, and acrid; its ſmell is only a little aromatic; it communicates an high red colour to the tincture of turnſol.

Heat, while it volatilizes this acid, increaſes its ſmell amazingly. When expoſed in a ſilver ladle to the heat produced

produced by the blow-pipe, it becomes liquid, as has been obſerved by M. Lichtenſtein, and evaporates without inflammation. When ſuffered to cool, it forms a ſolid cruſt, which exhibits on its ſurface ſome marks of cryſtallization in divergent radii. It does not burn with flame, unleſs when in contact with bodies that are burning with a ſtrong flame. Burning coal only ſublimates it rapidly.

Air appears to have no power of acting on this acid; for after being preſerved twenty years in a glaſs-veſſel, a quantity of it was ſtill very pure, and had loſt nothing of its weight: it loſes its ſmell indeed; but that it regains by heat.

The benzoic acid is ſcarce ſoluble in cold water. It appears from the experiments of Meſſrs Wenzel and Lichtenſtein, that 400 grains of cold water diſſolve no more than one grain of this acid; but the ſame quantity of boiling water diſſolves twenty grains of it; nineteen of which are ſeparated by cooling. Bergman ſays, that boiling water diſſolves one twenty-fourth of its own weight, and that water of a moderate temperature diſſolves ſcarcely one five-hundredth part.

The benzoic acid combines with all earthy and alkaline baſes, forming with them benzoates of aluminous earth, barytes, magneſia, lime, potaſh, ſoda, and ammoniac. We know not the particular characteriſtic properties of each of theſe combinations, nor the different affinities of the acid with each of theſe baſes. M. Lichtenſtein aſſerts, that it prefers the fixed alkalis, and even ammoniac, to aluminous, magneſian, or calcareous earth; but a great many more experiments are neceſſary to determine exactly the order of theſe affinities:

ties: And theſe are the more neceſſary, becauſe Bergman has given a different account of them. According to him, lime ſeparates the alkaline baſes, and barytes ſeparates lime: it diſengages carbonic acid from all of theſe baſes.

The concentrated ſulphuric acid diſſolves it eaſily without either noiſe or heat, according to the ſame chemiſt; but paſſes, in conſequence of effecting this ſolution, into the ſtate of ſulphureous acid; the benzoic acid may be ſeparated from it unaltered by water.

The nitric acid likewiſes diſſolves it, and gives it up in the ſame manner to water without alteration. M. de Morveau has cauſed theſe two bodies to re-act on each other with additional force by the application of heat. The nitrous gas was not diſengaged till the end of the operation; and the benzoic acid was ſeparated without loſs, and without alteration. M. Hermſtadt, however, ſays, that when the concentrated nitrous acid is employed, the benzoic acid becomes fluid, and more fixed in its nature, and aſſumes the characteriſtics of the tartareous or oxalic acid: but new reſearches are neceſſary to eſtabliſh the truth of this reſult, to which little confidence can at preſent be given. That which appears to be moſt certain concerning this acid is, that it differs in its nature and properties from all other vegetable acids, and retains in it an eſſential oil, to which it owes its ſmell, volatility, combuſtibility, and ſolubility, in alcohol.

CHAP.

ROYAL ... BRANCH ... SOCIETY

CHAP VI.

Of Vegetable Acids, partly ſaturated with Potaſh, and of the ſame Acids pure.

IN the fourth chapter, we mentioned a particular claſs of vegetable acids; which, we ſaid, were in part combined with potaſh. We know of two acids of this character, the acid of tartar, and the acid of ſorrel. We call theſe acids which are partly neutralized, *acidulæ*; the one is the tartareous, the other the oxalic.

§ I. *Of the Tartareous Acidula, or Tartar, and of the pure Tartareous Acid.*

THE tartar ſold in the ſhops is an eſſential acid ſalt, combined with a portion of potaſh and of oil, which is depoſited on the ſides of hogſheads containing wine, during the inſenſible fermentation of the wine. It is not, as ſome chemiſts have thought, a product of vinous fermentation;

mentation; for Rouelle the younger has found it fully formed in muſt and in verjuice. Many other chemiſts have ſince found it fully formed in various fruits.

It is in the form of irregular plates arranged in ſtrata, often full of brilliant cryſtals, and of an acid vinous taſte. It is diſtinguiſhed into white and red tartar; the latter of which differs from the former only in containing a greater quantity of colouring extractive matter.

Crude tartar, when expoſed to fire in cloſe veſſels, affords a reddiſh acid phlegm, an oil that is at firſt light, but afterwards ponderous, coloured, and empyreumatic, a little ammoniac, and a great quantity of carbonic acid, which Hales, Boerhaave, and many other chemiſts have taken for air. There remains a coal which contains a good deal of carbonate of potaſh, and is eaſily incinerated. By the combuſtion and incineration of tartar, fixed alkali is obtained in a ſtate of conſiderable purity. For this end, the tartar reduced to powder is put into rolls of paper ſteeped in water; they are then put into a furnace between two layers of coal; the coal is kindled, and the tartar is then burnt and calcined: when the fire is extinguiſhed, the rolls are taken out, and are found to retain their form; the matter which they contain is lixiviated with cold diſtilled water: This lixivium is filtered, and evaporated to a pellicle; it is ſuffered to cool, in order to ſeparate from it the ſulphate of potaſh, which is formed by reſt; the water is decanted from above this ſalt, and it is evaporated and cryſtallized anew, till it ceaſe to yield ſulphate of potaſh; it is then evaporated to dryneſs, and by this means affords

potaſh, partly cauſtic, and partly combined with carbonic acid.

It is very difficult to diſſolve tartar in water; for an ounce of water, 10 degrees above the freezing point, diſſolves only four grains of tartar. As it contains a good deal of oily colouring matter, it is purified by ſolution and cryſtallization at Aniaen and Calviſſon, in the neighbourhood of Montpelier. Doctor Fizes favoured the public with an account of this purification, in a Memoir printed among the Memoirs of the Academy for the year 1725.

The tartar is boiled in water; the boiling ſolution is filtrated; as it cools it becomes turbid, and depoſites irregular cryſtals, which form a paſte. This paſte is boiled in copper veſſels with water, in which there is a mixture of clayey earth, which comes from the village of Merviel, two leagues diſtant from Montpelier. A froth gathers on the ſurface of the liquor, which is carefully ſkimmed off, and is ſucceeded by a ſaline pellicle. The fire is then abated; and the pellicle being broken, mixes with the cryſtals which are precipitated from the ſolution: theſe cryſtals are waſhed with water, to purify them entirely from a mixture of earth, with which they are contaminated, and ſold under the name of *cream* or *cryſtals of tartar;* the only difference between the cream and the cryſtals being, that the cream is cryſtallized on the ſurface, whereas the cryſtals are depoſited at the bottom of the liquor. The white clay appears to ſerve the purpoſe of ſeparating from the tartar the ſuperfluous oily and extractive matter which it contains.

At Venice, tartar is purified in a way ſomewhat different from this, according to M. Deſmaret's account. The ſalt is reduced to powder, and diſſolved in boiling water; it is ſuffered to depoſite any impure matters which it contains; and theſe are carefully taken out: the liquor then affords cryſtals by reſt and cooling. Theſe cryſtals are again diſſolved in water, which is expoſed to a gentle heat: when this new ſolution is heated to ebullition, beaten whites of eggs and aſhes, previouſly paſſed through a ſieve, are put into it. This mixture of aſhes is repeated 14 or 15 times; the ſcum produced by the efferveſcence of the liquor is taken off; and it is then ſuffered to ſettle. A pretty white pellicle, and ſaline cryſtals of the ſame colour, are ſoon formed: the water is then decanted off, and the ſalt dried. By this method the nature of the tartareous acidulum is in ſome degree altered, and a part of it is changed into tartarite of potaſh. The cream of tartar, or purified tartar of Montpelier, muſt be the ſubject of our examination, in order that we may underſtand the nature of the pure tartareous *acidulum*.

The tartareous acidulum, when very pure, is cryſtallized, but in an irregular manner. Its taſte is ſour, and not ſo vinous as that of crude tartar. When it is put on a burning coal, it diffuſes a good deal of ſmoke of a pungent empyreumatic ſmell; and becomes black and carbonaceous. When this ſubſtance is ſubmitted to diſtillation in an earthen retort, with a balloon terminating in a tube, entering a bell-glaſs full of water, it affords, if the fire be gradually applied to it, a phlegm which is at firſt a little coloured, and ſomewhat acid:

there

there paſſes after this an acid which is ſtronger and of a deeper colour; an oil which by degrees acquires colour and conſiſtency, and has an empyreumatic ſmell; ammoniacal carbonate; and a large quantity of carbonic acid. In the retort, there remains a good deal of coal, which, when lixiviated without incineration, affords a large proportion of potaſh. All of theſe products may be rectified by a new diſtillation at a moderate fire. The phlegm paſſes almoſt colourleſs; the oil, by this rectification, becomes very white and volatile; the ammoniac is in part combined with the acid, and can only be obtained ſeparate and pure by diſtilling the laſt portions of the phlegm with an addition of potaſh. With reſpect to the coal, the potaſh which it contains is not produced in the courſe of the operation, as has been thought by ſome chemiſts not well acquainted with the nature of *cream of tartar*; but exiſts in it ready formed before the operation. The production of the ammoniac is owing to the re-action of this alkali on the oil. A ſtill greater quantity of the volatile ſalt may be obtained by diſtilling the oil obtained from the tartareous acidulum upon the coal which it leaves, when analyſed in the retort. The proximate cauſe of the formation of the ammoniac is the combination of the azote of the potaſh with the hydrogene diſengaged from the oil.

The tartareous acidulum ſuffers no alteration from air. It diſſolves in twenty-eight parts of boiling water, and cryſtallizes by cooling, but in a very confuſed manner. There is a certain quantity of earth ſeparated from the ſolution of this ſalt, which, no doubt, is a part of the earth that was employed to purify it. This ſo-

lution reddens the tincture of turnſol, and has an acid taſte. When left expoſed to the air, it becomes turbid, and, after ſome time, depoſites mucilaginous flakes: the acid is then decompoſed, and the liquor is, after this, found to contain nothing but carbonate of potaſh. M. de Machy was the firſt who obſerved this decompoſition. Meſſrs Spielman and Corvinus likewiſe attended to it; but M. Berthollet has obſerved it with ſtill greater accuracy than any former philoſopher. He has obſerved, that two ounces of tartareous acidulum require eighteen months before they can be entirely decompoſed; that theſe two ounces will afford, in that time, ſix and a half drachms of carbonate of potaſh, ſtill oily, and mixed with a ſmall quantity of carbonaceous matter; and that, therefore, the quantity of alkali obtained by this means from the tartareous acidulum is preciſely the ſame which it would afford by combuſtion and calcination. The alkaline reſidue which remains after the diſtillation of this acidulum, and this ſpontaneous decompoſition, prove, therefore, that it contains a proportion of potaſh, nearly equal to one-fourth of its weight.

We know nothing of the action of ſiliceous, and very little of the action of aluminous earth, and barytes on the tartareous acidulum. The chemiſts of the Academy of Dijon have obſerved, that magneſia forms with this acidulum a ſoluble ſalt, liable to be decompoſed by fixed alkali; the ſolution of which affords, by evaporation in the open air, ſmall priſmatic radiated cryſtals. When expoſed to fire, this tartarited magneſia emits bubbles, and is converted into a light coal. M. Poulletier de la Salle obtained from this combination, a gelatinous maſs,

perfectly

perfectly like a mucilage. Theſe phænomena depend on the particular ſtate of the tartareous acidulum, which is in part ſaturated in this acidulated vegetable acid.

A number of chemiſts have given very good deſcriptions of the manner in which lime and chalk affect the tartareous acidulum. When chalk is caſt into a ſolution of this acidulum, an effervescence takes place, owing to the diſengagement of the carbonic acid, and a very copious precipitate is formed; the precipitate is a combination of lime with the tartareous acidulum. The ſupernatant liquor contains a neutral ſalt ready formed in the acidulum, or *cream of tartar*, which conſiſts of the pure acid in union with potaſh: This ſalt, as we will hereafter ſee, has been improperly called *ſoluble tartar*. We are indebted to Roueſle the younger for this analyſis of the tartareous acidulum by chalk. It proves, 1. That this ſubſtance conſiſts of an exceſs of oily acid, and a certain quantity of the ſame acid, united with potaſh in the ſtate of a neutral ſalt. 2. That the combination of the tartareous acid with lime, forms a neutral ſalt, which is ſcarcely ſoluble. M. Prouſt has diſcovered, that calcareous tartarite, diſtilled in a retort, leaves a reſidue that takes fire in the air like the pyrophorus.

The tartareous acidulum very readily combines with the different alkalis. Put into a ſolution of carbonate of potaſh a quantity of tartareous acidulum in powder; a lively effervescence is produced by the diſengagement of the carbonic acid: let acidulum be added till the alkali be ſaturated; after boiling this liquor for half an hour, filtrate it, evaporate the filtrated liquor to a pel-

licle, and ſuffer it to cool ſlowly; oblong ſquare cryſtals, terminating ſlopewiſe at two of their extremities, will be formed. This ſalt has been called *vegetable ſalt, ſoluble tartar, tartarized tartar;* but it ought to be called *tartarite of potaſh.* Its taſte is bitter; when expoſed to a ſtrong heat, it becomes carbonaceous: it may be decompoſed in a retort; and it then affords an acid phlegm, oil, a good deal of carbonic acid, and a little ammoniacal carbonate. It attracts, in ſome degree, the moiſture of the atmoſphere. It diſſolves in four parts of water heated to the temperature of 40°. This ſolution is decompoſed of itſelf in a few months; and it then leaves tartareous acidulum in combination with carbonic acid. The mineral acids decompoſe it, and precipitate the tartareous acidulum. It is alſo decompoſed by moſt metallic ſolutions.

The tartareous acidulum, combined with ſoda, forms the *ſalt of Seignette,* who was an apothecary of Rochelle, and the firſt that made up this combination: we give it the name of *tartarite of ſoda.* To prepare it, put 20 ounces of the acidulum of tartar into four pounds of boiling water; add by degrees very pure cryſtallized carbonate of ſoda, till the acidulum be ſaturated; that is, till the addition of the alkaline ſalt no longer produce any efferveſcence. This combination renders the tartareous acidulum ſoluble. Evaporate the liquor almoſt to the conſiſtency of ſyrup; and you then obtain from it, by cooling, very beautiful and regular cryſtals, often of a conſiderable ſize. Theſe are priſms with ſix, eight, or ten, unequal ſides, with their extremities truncated at right angles. Theſe priſms are generally divided longitudinally into two; and the baſe on which

they ſtand is marked with two diagonal lines, which croſs each other ſo as to divide it into four triangles. Tartarite of ſoda, which was at firſt ſold as a ſecret, and which was diſcovered at the ſame time by both Boulduc and Geoffroy in the year 1731, has a bitter taſte. It is decompoſable by fire, like tartarite of potaſh; it efflores̃ces in the air, on account of its containing a good deal of water in its cryſtals: it is almoſt as ſoluble as tartarite of potaſh; and is, like it, decompoſable by air, by mineral acids, and by metallic ſolutions. The mother-water of this ſalt contains that portion of tartarite of potaſh which entered into the compoſition of the tartareous acidulum.

Ammoniac forms with the acidulum of tartar an ammoniacal tartarite, which cryſtallizes very well by evaporation and cooling. Bucquet ſays, that its cryſtals are rhomboidal pyramids. Macquer ſaw ſome of them in large priſms, of four, five, or ſix ſides; others ſwelled in the middle, and terminating in very acute points; and the Academicians of Dijon obtained this ſalt in parallelopipeds, with two alternate ſloping ſides. This ſalt, ammoniacal tartarite, has a freſh taſte, and is decompoſable by fire: it efflores̃ces in the air; it is more ſoluble in hot than in cold water; and it cryſtallizes by cooling: lime and the fixed alkalis diſengage the ammoniac; the contact of air, mineral acids, and metallic ſolutions, decompoſe it. It appears, that when this ſalt is prepared, the tartarite of potaſh, which, in union with the tartareous acid, conſtituted the acidulum, or *cream of tartar*, remains in the mother-water.

Pott and Margraff have treated the tartareous acidulum with mineral acids; and the latter obtained neutral

ſalts, the ſame with thoſe which the ſame acids form with potaſh: from which he has inferred, that potaſh exiſts ready formed in the acidulum. Rouelle the younger, who proſecuted a ſimilar train of experiments, obtained the ſame reſults. On throwing a pound of concentrated ſulphuric acid on an equal weight of tartareous acidulum in a very fine powder, the mixture becomes hot; the reciprocal action of the two ſubſtances may be promoted by the heat of a *balneum mariæ*, and by ſtirring them with a ſpatula of glaſs: let the heat be continued for ten or twelve hours; the mixture will then become thick like a jelly: then pour upon it two or three ounces of boiling diſtilled water, to render it fluid; and leave it on the *balneum-mariæ* for about two hours; then take off the fire, and add three pints of boiling diſtilled water: the ſolution is now coloured and opaque; it contains naked ſulphuric acid, a portion of tartareous acidulum, not decompoſed, and ſulphate of potaſh. Saturate the exceſs of ſulphuric acid with chalk; a precipitate of ſulphate of lime, with a ſmall portion of tartareous acidulum, is then produced: filtrate the mixture, and evaporate the filtrated liquor; it now affords ſo much tartareous acidulum and ſulphate of lime, that it is reduced to eighteen or twenty ounces. It is next decanted and evaporated anew; and it affords, by reſt, cryſtals of ſulphate of potaſh; which may be thus obtained by repeated evaporation and cryſtallization, till the whole ſolution be exhauſted. This ſalt is always mixed with a little of the tartareous acidulum, and it burns upon red iron; but when lixiviated with a ſufficient quantity of diſtilled water, it is diſſolved, and the acidulum remains on the bottom of the veſſel.

This proceſs has been deſcribed, and ſucceſsfully repeated, by M. Bemiard, after Rouelle.

The nitric and the muriatic acids, when treated in the ſame manner with the tartareous acidulum, afford nitrate and muriate of potaſh; which proves incontrovertibly the exiſtence of potaſh in that ſubſtance.

The tartareous acidulum acquires ſolubility by union with borax and the boracic acid. According to the experiments of M. de Laſſone, one part of the latter ſalt will render four parts of the tartareous acidulum ſoluble. This mixed ſolution affords, by evaporation, a greeniſh gummy ſalt, which is very acid. Common borax, when added to the tartareous acidulum, converts a part of the acid into tartarite of ſoda, in conſequence of the ſoda which it contains.

The tartareous acidulum appears to be capable of uniting, without decompoſition, with moſt metallic ſubſtances; as has been ſhown by M. Monnet, and the chemiſts of the Academy of Dijon. But as all of theſe combinations have been but very little examined, we ſhall here ſpeak only of thoſe in which the acidulum is combined with antimony, mercury, lead, and iron; becauſe theſe compounds are better known, and are moſtly employed in medicine.

The combination of the tartareous acidulum with antimony bears the name of *ſtibiated*, or *antimoniated tartar*. It conſiſts of tartarite of antimony and potaſh. As it is one of the moſt valuable medicines which chemiſtry can ſupply, we muſt examine its properties with care. Since the time of Adrian, who firſt made it known to the world in the year 1631, the method of preparing

it

it has been much varied. All the pharmacopœiæ, as well as the works of chemiſts, differ, either in reſpect to the antimonial ſubſtances to be employed in this preparation, or in reſpect to the proportions in which theſe, the water, and the tartareous acidulum, are to be mixed; or, laſtly, in reſpect to the proceſs by which theſe ſubſtances are to be united in ſtibiated tartar. In Bergman's Diſſertation on this medicine, there is an excellent table of the various proceſſes which have been given for the preparation of tartarite of antimony. The ſublimated vitreous white oxide, the brown, and the orange-coloured oxides of antimony, have been ſucceſſively recommended for this purpoſe. Some have directed to boil theſe ſubſtances with the tartareous acidulum, and a greater or a leſs proportion of water, for ten or twelve hours; others think half an hour's boiling ſufficient: laſtly, ſome writers prefer the evaporation of the filtrated lixivium to dryneſs; while others would have it to be cryſtallized, and only the cryſtals uſed in medicine. From theſe various modes of preparation, it happens, that tartarite of antimony can ſcarce ever be purchaſed twice preciſely of the ſame ſtrength and nature; and its effects can never be depended upon. Geoffroy, who had examined ſeveral ſorts of *ſtibiated tartar* of different degrees of ſtrength, found by analyſis, that the weakeſt *ſtibiated tartar* contains in the ounce from thirty grains to a dram and eighteen grains of oxide of antimony: that which is moderately emetic, a dram and a half; and that which acts with moſt energy, no leſs than two drams and ten grains. The vitreous oxide of antimony

mony has been preferred to other antimonial ſubſtances for this preparation; becauſe it diſſolves eaſily by the acidulum of tartar: but this metallic glaſs may happen to be more or leſs oxidated: and according as it is more or leſs oxidated, it will be more or leſs emetic. However, a tranſparent vitreous oxide of antimony, levigated, and boiled in water with an equal quantity of tartareous acidulum, till the latter be completely ſaturated, then filtrated and evaporated by a moderate heat, affords, by reſt and cooling, cryſtals of antimoniated tartarite; the effects of which, as emetics, may be ſafely depended upon. Decant the liquor, evaporate it, and you obtain by ſucceſſive evaporation a new quantity of cryſtals. The mother-water contains ſulphur and tartarite of potaſh, with a certain quantity of antimoniated alkaline ſulphure. When the mixture of tartareous acidulum, vitreous oxide of antimony, and water, which were boiled for the preparation of antimoniated tartarite, is filtrated, there remains on the filter a ſeemingly gelatinous, yellow, or brown matter, of which Rouelle has taken notice. According to M. Prouſt, this jelly, when diſtilled, affords a very inflammable pyrophorus.

Macquer has propoſed the uſe of white oxide, precipitated from muriate of antimony by water, inſtead of the vitreous oxide of antimony. This oxide is a violent emetic; and Macquer thought it conſtant in its effects. Bergman has adopted Macquer's opinion; and in the laboratory of the Academy of Dijon, tartarite of antimony has been ſince prepared, according to the method of that chemiſt and M. de Laſſone. This preparation has been very ſucceſsfully employed: the requiſite doſe is three grains; and this quantity does

does not affect the ſtomach or the inteſtines too violently.

Tartarite of antimony cryſtallizes in trihædral pyramids. It is very tranſparent; it is decompoſed, and rendered carbonaceous by fire; in the air, it efflorèſces, takes a dead white colour, and becomes farinaceous. It diſſolves in ſixty parts of cold water, and in a much ſmaller proportion of boiling water; it cryſtallizes by cooling; alkalis and lime decompoſe it. Calcareous earth and pure water in a large proportion, are capable of decompoſing it; and it ſhould therefore be adminiſtered only in diſtilled water. Alkaline ſulphures, and ſulphurated hydrogenous gas, produce in its ſolution a precipitate of a red powder, which is a kind of ſulphurated oxide of antimony; and may be employed to aſcertain the preſence of this ſalt in any liquor with which it may happen to be mixed. Iron ſeizes the tartareous acid, and ſeparates the oxide of antimony: ſtibiated tartar, therefore, ſhould not be prepared in iron veſſels. M. Durande, a phyſician and profeſſor at Dijon, has propoſed, that this medicine ſhould be publicly prepared by one uniform proceſs, in the ſame manner as theriaca. Such a method could not but be very advantageous; the phyſicians might then all depend on the effects of this medicine. It appears that tartarite of antimony contains that portion of tartarite of potaſh which entered into the compoſition of the tartareous acidulum; and is therefore a ſort of triple ſalt. The tartareous acid may be combined with mercury in two ways. The one, which is mentioned by M. Monnet, conſiſts in diſſolving in boiling water ſix parts of the tartareous acidulum with one part of oxide of mercury, precipi-

tated

tated from the nitric acid by carbonate of potaſh. This liquor, by filtration and evaporation, afforded him cryſtals, which were decompoſed by pure water. The ſecond method of combining mercury with the tartareous acidulum, is, by pouring a nitric ſolution of this metal into a ſolution of tartarite of potaſh or ſoda: a precipitate is thus obtained, which conſiſts of mercurial tartarite; and the nitrite of potaſh or ſoda remains diſſolved in the liquor.

The tartareous acidulum acts in a ſenſible manner upon oxide of lead. Rouelle the younger obſerved, that the tartarite of lead formed in this operation does not remain diſſolved in the liquor; and that the liquor, when evaporated, affords only pure tartarite of potaſh, which exiſted, ready formed, in the tartareous acidulum. This is one of the proceſſes which he employed to aſcertain the preſence of potaſh in tartar.

Copper and its oxides are eaſily acted upon by the tartareous acidulum: the reſult is a beautiful green ſalt, ſuſceptible of cryſtallization; but it has not hitherto been carefully examined.

Iron is one of thoſe metals on which the tartareous acidulum acts with the greateſt efficacy. A medicine, called *chalybeated tartar*, is prepared by oiling four ounces of levigated iron filings, with a pound of white tartar, in twelve pounds of water. When the tartar is diſſolved, the liquor is filtrated: it depoſites cryſtals; and theſe may be repeatedly obtained by evaporating the mother-water. To prepare *tartarized tincture of Mars*; make a paſte of ſix ounces of iron filings, a pound of white tartar in powder, and a ſufficient quantity of water: let this mixture ſtand undiſturbed for twenty-four hours;

hours; next, dilute it in twelve pounds of water, and boil the whole for two hours, adding water to ſupply the room of that which is evaporated; decant off the liquor, filtrate it, and concentrate it to the conſiſtency of a ſyrup, adding an ounce of alcohol. Roulle obſerved, that the potaſh exiſts at liberty in this tincture; and that, by treating it with acids, neutral ſalts are obtained; which demonſtrate beyond a doubt the preſence of the alkali. There are two other medicines formed by the combination of the tartareous acid with iron; one of theſe is *ſoluble martial tartar*, which is a mixture conſiſting of a pound of *tartarized tincture of Mars*, with four ounces of tartarite of potaſh, evaporated to dryneſs. The other is known by the name of *balls of Mars*. Theſe are prepared by putting one part of filings of ſteel, with two parts of white tartar in powder, into a glaſs veſſel, with a certain quantity of brandy: when the liquor is evaporated, pulverize the maſs, and add more brandy, which evaporate again as before: repeat this proceſs till the mixture become greaſy and tenacious; then make it up into balls.

Crude tartar is of great uſe in dyeing; hat-makers likewiſe make uſe of it.

The ſeveral preparations of the tartareous acidulum, which we have here enumerated, are chiefly employed in medicine. The pure tartareous acidulum is thought to be refreſhing and antiſeptic; in doſes of half an ounce, or an ounce, it acts as a gentle purge, without exciting nauſea. Tartarite, both of potaſh and ſoda, is frequently taken in doſes of a few drams, to aſſiſt the action of other purgative medicines. Tartarite of antimony is one of the moſt uſeful and moſt powerful medicines which che-

miſtry

miſtry affords. This ſalt is emetic, purgative, diuretic, diaphoretic, or diſcuſſive, according to the doſes, and the circumſtances in which it is adminiſtered. It often produces even all theſe effects at once. It may be conſidered as a powerful alterative, happily qualified to remove obſtructions in the viſcera, when adminiſtered in ſmall and repeated doſes. It is given as a vomit in doſes of from one to four grains, diſſolved in a few glaſſes of water. A grain of it is ſometimes mixed with other medicines to aſſiſt their action: laſtly, It acts as an alterative when taken, half a grain at a time, diluted in a large proportion of water. M. de Laſſone has diſcovered, that tartarite of antimony is rendered very ſoluble in water, by mixing with it ammoniacal muriate; and that there reſults from this mixture a ſalt of a nature ſimilar to that of ammoniaco-mercurial muriate. This new triple ſalt cannot but produce very powerful effects on the animal œconomy. *Chalybeated tartar*, *ſoluble martial tartar*, and the *tartarized tincture of Mars*, are employed as tonics and aperitives.

Such are the properties of the native tartareous acidulum, or of the tartareous acid, combined by nature with a certain quantity of potaſh. It was requiſite to examine it with care, as it is ſo very uſeful, and ſo very much employed. But this is not the pure tartareous acid; and it is of no leſs importance to know the characteriſtic properties of that ſubſtance. M. Retzius has publiſhed, in the Memoirs of Stockholm for the year 1770, a proceſs invented by Scheele for extracting and purifying this acid. Into a ſolution of two pounds of the tartareous acidulum, in boiling water, put waſhed chalk, till ſuch time as it ceaſe to produce effervescence, and

and there be no longer any of the acid in a ſtate of liberty: the quantity requiſite is ſomewhat more than a fourth part of the weight of the acidulum; take out the precipitate of calcareous tartarite which is now formed, place it on a filtre, and waſh it with cold water; there are uſually thirty-two or thirty-three ounces of it, on account of its containing water. The liquor decanted from above the precipitate, affords by evaporation a quantity of tartarite of potaſh, which has not been decompoſed, equal nearly to half the acidulum employed. Pour upon the calcareous tartarite, in powder, nine and a half ounces of concentrated ſulphuric acid, diluted in five pounds five ounces of water; leave this mixture to digeſt for twelve hours, ſtirring it from time to time. Decant the liquor from above the ſulphate of lime; evaporate it, after aſcertaining that it contains no ſulphuric acid. In order to that, pour into it a few drops of acetite of lead, or ſalt of Saturn: if the precipitate thus produced be ſoluble in vinegar, the lixivium may be inferred to contain no ſulphuric acid; but if the precipitate cannot be diſſolved in that fermented acid, the lixivium ſtill contains ſulphuric acid, which may be ſeparated by digeſting it on a certain quantity of calcareous tartarite. Lime may be uſed inſtead of chalk in the proceſs for obtaining the tartareous acid: But as that alkaline earth decompoſes the tartarite of potaſh contained in the tartareous acidulum, the lixivium, when lime is uſed, contains only alkali inſtead of tartarite of potaſh, as in the former proceſs. The uſe of quicklime in this decompoſition affords more of the acid, becauſe lime decompoſes twice its weight of tartareous acidulum.

The

The pure tartareous acidulum obtained in a liquid ſtate by either of theſe proceſſes, muſt be evaporated to dryneſs; then diſſolved again, and cryſtallized, either by ſlow evaporation, according to M. Pæcken; or by cooling the evaporated liquor to the conſiſtency of a clear ſyrup, according to Bergman. It is obtained in the form of ſmall ſharp-pointed needles, or minute priſms; the form of which it is ſcarce poſſible to determine. Bergman deſcribes them as divergent leaves; M. Retzius compares them to hairs intwined together: They are at firſt very white; thoſe obtained towards the end of the operation are yellow.

The cryſtallized tartareous acid melts, fumes, becomes black, and even takes fire, when brought into contact with burning bodies. When diſtilled, it affords, like the tartareous acidulum, only an acid phlegm, a little oil, and a good deal of gazeous carbonic acid, mixed with carbonated hydrogenous gas. The coal which remains contains neither acid nor alkali; which proves, that no alkali is formed in conſequence of the decompoſition of the tartareous acid by fire: this acid, however pure, is always oily. For this reaſon, it is called the *tartareous acid*, and its ſalts *tartarites*.

It is not liable to alteration in the air: It is much more ſoluble than the tartareous acidulum: Its taſte is very pungent: It reddens the tincture of violets, as well as that of turnſol. It diſſolves aluminous earth, and forms with it an aluminous tartarite, which takes only a gummy or mucilaginous conſiſtency by evaporation.

In combination with magneſia, the pure tartareous

acid forms a ſalt; which alſo, inſtead of cryſtallizing, gives a ſort of gelatinous matter.

By combination with lime, it affords an almoſt inſoluble ſalt.

A little potaſh, poured into this ſolution, precipitates the tartareous acidulum, or *cream of tartar*, in cryſtals. This diſcovery, made by Scheele and Bergman, throws more light than any other facts known on the nature of this vegetable ſalt. No farther proofs are requiſite, as M. de Morveau ſays, to determine the principles of which the tartareous acidulum conſiſts: we know it to conſiſt of tartarite of potaſh, with exceſs of acid; but, what is very ſingular, this acid, naturally very ſoluble, ſuddenly loſes that property when about half ſaturated with potaſh; which, however, is very ſoluble by itſelf. This fine experiment alſo proves, that the tartareous acid is not in any manner altered by Scheele's proceſs; for with about one fourth or one third of its own weight of potaſh, it forms an acidulous ſalt, ſimilar in nature to the acidulum from which it was obtained. With a greater proportion of potaſh, it forms a neutral ſalt, completely ſaturated and ſoluble, which is tartarite of potaſh, or *vegetable ſalt*.

The tartareous acid, with ſoda, forms a cryſtallizable neutral ſalt, or tartarite of ſoda (*ſalt of Seignette*), which is very pure. With ammoniac, it affords a cryſtallizable ammoniacal tartarite. M. Retzius informs us, that the tartareous acid, when combined with a quantity of ammoniac conſiderably leſs than what is required to ſaturate it, forms a ſcarce ſoluble ammoniacal tartareous acidulum, which cryſtallizes like the

common

common cream of tartar, or tartareous acidulum of potaſh.

Although the tartarites have not ſo ſtrong an affinity with the alkalis, as the mineral acids; yet theſe latter ſalts, when they decompoſe tartarite of potaſh or ſoda, do not completely ſeparate the baſe, but diſengage the tartareous acid into the ſtate of acidulum, of potaſh, or of ſoda. The pure tartareous acid does itſelf partly decompoſe ſulphate, nitrate, and muriate of potaſh, and ſeparates ſo much of the alkali as is requiſite to bring it into the ſtate of tartareous acidulum, or acidulated tartarite of potaſh. It does not produce the ſame effect on nitrate and muriate of potaſh.

M. Hermſtadt aſſerts, that the tartareous becomes oxalic acid by means of the nitrous acid. Bergman could not effect this change: but he failed probably on account of employing too little of the nitrous acid. As the nitrous acid gives out nitrous gas, when it accompliſhes the tranſmutation of the tartareous acid, the only difference between the tartareous and oxalic acids would appear to be, that the latter contains a greater quantity of oxigene.

The tartareous acid is incapable of acting on ſilver, gold, or platina; it diſſolves their oxides. Its action on copper, lead, and tin, is imperceptible: it diſſolves the oxides of theſe metals, and deſtroys the red colour of oxide of lead.

It diſſolves iron with a very gentle effervescence.

It produces no alteration on antimony in a metallic ſtate, but acts with ſufficient force to diſſolve its oxides.

It ſeparates lime from the nitric, the muriatic, the acetous, the formic, and the phoſphoric acids.

It precipitates the nitric ſolution of mercury, the muriatic ſolution of lead, &c.

Its attractions are repreſented by Bergman in the following order: lime, barytes, magneſia, potaſh, ſoda, ammoniac, aluminous earth; oxide of zinc, iron, manganeſe, cobalt, nickel, lead, tin, copper, biſmuth, antimony, arſenic, ſilver, mercury, gold, platina, water, and alcohol.

§ II. *Of the Oxalic Acidulum, or Salt of Sorrel, that is ſold in commerce, and of the pure Oxalic Acid.*

THE ſalt of ſorrel ſold in the ſhops, or the oxalic acidulum, is extracted in great quantities at Hartz, in Thuringia and Swabia, from the juice of ſorrel, called by Linnæus *oxalis acetoſella*. An hundred pounds of this plant, cut down in a ſtate of vigorous vegetation, afford, according to M. Savary, fifty pounds of expreſſed juice; which fifty pounds of juice afford only five ounces of concrete ſalt, by evaporation and cryſtallization. The ſalt of ſorrel that comes from Switzerland, is diſtinguiſhed in commerce as the moſt beautiful and the whiteſt; that from Forets in Thuringia is dirty and yellowiſh.

The juice of ſorrel has been long known to afford an acid ſalt by evaporation. Duclos mentions it in the Memoirs of the Academy for 1668: Juncker likewiſe ſpeaks of it. Boerhaave, who compares this ſalt to tartar, has given a very accurate deſcription of the

proceſs

proceſs for obtaining it. M. Margraff diſcovered, that potaſh entered into the oxalic, as well as into the tartareous acidulum. But the nature of this ſalt was by no means exactly known, till the experiments of Meſſrs Savary, Wenzel, Wiegleb, Scheele, and Bergman, were communicated to the world.

The oxalic acidulum exiſts in ſmall white cryſtals, opaque, and needled or lamellated. Their form has not been yet fully aſcertained; although Capeller and Ledermuller have deſcribed them as they appeared through the microſcope. M. de Liſle repreſents them as very oblong parallelopipids. They conſiſt of collections of long thin leaves, joining at one end, but ſeparate at the other. The taſte of this ſalt is ſour, poignant, and at the ſame time bitter. It communicates a deep red colour to tincture of turnſol, and blue paper. Four hundred and eighty grains of this acidulum, diſtilled in a retort by a fire, the heat of which was properly regulated, afforded M. Weigleb one hundred and fifty grains of phlegm, ſtrongly acid, without either ſmell or colour. There remained one hundred and ſixty grains of grey ſalt, from which one hundred and fifty-ſix grains of vegetable alkali were obtained. About four grains of concrete acid ſalt were likewiſe ſublimed into the neck of the retort: not a drop of oil paſſed. In this proceſs of diſtillation, there were one hundred and ſixty-ſix grains of loſs. But as M. Weigleb does not mention what elaſtic fluids were diſengaged in this analyſis, the loſs was probably owing to the diſengagement of water in vapours, and of carbonic acid gas, mixed with a little hydrogenous gas and carbonaceous matter. By comparing this analyſis

with that of the tartareous acid, we perceive the oxalic acidulum to be leſs oily than the other The liquid acid, therefore, obtained by this diſtillation, is pure oxalic acid; whereas the tartareous acidulum, when treated with fire, affords an altered acid, different in nature from the tartareous acid, which we call the *pyro-tartareous acid.* It is becauſe the acid of ſorrel contains ſo little oil, that we call it the *oxalic acidulum* and *acid;* while to the more oily acid of tartar, the rules of our methodical nomenclature require us to give the name of the *tartareous acid.*

The oxalic acidulum, when pure, ſuffers no alteration by expoſure to air; it is more ſoluble than the tartareous acidulum. According to M. Weiglib, a drachm of oxalic acidulum from Switzerland requires to diſſolve it only ſix drachms of boiling water; but though other ſix drachms of cold water be added, it is entirely precipitated by cooling. According to M. Wenzel, it is even much more ſoluble than M. Weigleb repreſents it: for he found, by experiment, nine hundred and ſixty parts of boiling water to take up ſix hundred and ſeventy-five parts of this ſalt: but its ſolubility varies, according as it is more or leſs acid; which again depends on the quality of the plant from which it is extracted.

The oxalic acidulum combines with barytes, magneſia, ſoda, ammoniac, with which it forms triple ſalt (or *triſules*). Lime decompoſes it, by detaching its acid, both that part which is in a ſtate of liberty, and that which is in combination with the potaſh. One hundred grains of chalk decompoſe one hundred and thirty-ſeven grains of the oxalic acidulum. The precipitate

cipitate of calcareous oxalate that is depoſited, weighs one hundred and ſeventy-five grains; the ſupernatant liquor affords, by evaporation, thirty-two grains of carbonate of potaſh. This proceſs cannot be uſed in preparing the pure oxalic acid, though the tartareous acid be obtained pure by it: for calcareous oxalate is not decompoſable by ſulphuric acid, like calcareous tartarite; on the contrary, the oxalic acid has ſo ſtrong an affinity with lime, that it attracts this earth from all other acids; and one certain teſt of the purity of the oxalic acidulum, or ſalt of ſorrel, is, to pour a ſolution of it into water impregnated with calcareous ſulphate: when the acidulum has been really extracted from ſorrel, it produces in the water a copious precipitate.

The ſulphuric acid contributes to the diſengagement of the oxalic acid from the acidulum by means of heat, according to M. Weiglib. The nitric acid decompoſes the acidulum, and ſeparates the alkali; but it has much more difficulty to accompliſh this on the oxalic than on the tartareous acidulum, according to Margraff's experiments.

The oxalic acidulum acts upon iron, zinc, tin, antimony, and lead. It diſſolves the oxides of all the other metals, forming with them triple cryſtallizable ſalts, which are not deliqueſcent, and in which the potaſh always remains in union with the acid: it precipitates the nitric ſolutions of mercury and ſilver. M. Bayen, by evaporating the ſupernatant liquor from above theſe precipitates, obtained nitrate of potaſh, and thus eſtabliſhed more certainly the exiſtence of alkali in this acidulum.

To prepare the oxalic acid by ſeparating the potaſh of the acidulum, diſtillation, as we have already ſeen, may be employed: but this proceſs affords only a ſmall quantity; and that which Scheele has recommended, being eaſier performed, and more certain in its reſults, is therefore preferable. Saturate the oxalic acid with ammoniac; pour into this triple ſolution, conſiſting of oxalic acid, with ammoniac and potaſh, a quantity of barytic nitrate. A precipitate of barytic oxalate is thus produced, and the nitric acid retains the potaſh and ammoniac. After waſhing the barytic oxalate, decompoſe it with ſulphuric acid. The ſulphate of barytes, that is now formed, remains inſoluble at the bottom of the liquor. Decant off the liquor; ſeparate the portion of ſulphuric acid which may ſtill be contained in it, by barytic oxalate diſſolved in boiling water; and when it ceaſes to afford a precipitate, the liquid may be conſidered as containing pure oxalic acid, and decanted off from above the precipitate. It is next to be evaporated with proper care; and it now affords ſalt, by cooling, in quadrilateral priſms, with their ſides alternately broad and narrow, and terminating in dihædral ſummits. Theſe cryſtals are often in the form of ſquare or rhomboidal plates.

This concrete acid has a very ſtrong ſour taſte; ſeven grains communicate a ſenſible acidity to two pounds of water. It reddens all blue vegetable colours. A grain of this ſalt communicates to 3600 grains of water the property of reddening paper tinctured with turnſol.

The concrete oxalic acid, when expoſed to a moderate fire, becomes dry, and is covered over with a thick cruſt; it is in a ſhort time reduced to powder, and loſes three tenths of its weight. When diſtilled in a retort, by a ſtronger fire, which muſt not, however, be violent, it liquifies, becomes brown with ebullition, affords an acidulated phlegm, and is partly ſublimated without alteration. There is at the ſame time diſengaged from it a gas, mixed with carbonic acid, and hydrogenous gas. When expoſed to a violent heat, it affords more gas, leſs ſublimated concrete acid, and more acidulated phlegm, that is not liable to cryſtallization; at the bottom of the retort, there remains only a grey or brown maſs, amounting to one fiftieth part of the acid employed. When put upon a coal burning in the air, it emits a very acrid white ſmoke, which irritates the lungs in a very lively manner: the reſidue which it leaves is white, without any mixture of carbonaceous matter. Such is the reſult of the decompoſition of the oxalic acid by fire that was obſerved by Bergman. The Abbé Fontana has obtained near double the quantity of gas; but that, as we have already ſhown, depends on his having applied a ſtronger heat, with a view to effect a thorough decompoſition of the acid.

When expoſed to moiſt air, the concrete oxalic acid remains deliqueſcent; but in dry air it rather becomes dry. Cold water diſſolves a quantity of it equal to one half of its own weight. When cryſtals of this acid are caſt into cold water, a faint noiſe is heard, which muſt be produced by a ſudden breaking of their particles. The ſpecific gravity of this cold ſolution is 1.0593, according

cording to M. de Morveau. No acid vapour riſes with the water of the ſolution when evaporated, not even by ebullition. Boiling water diſſolves a quantity of this concrete acid ſalt equal to itſelf in weight: One half is precipitated in cryſtals by cooling.

The oxalic acid diſſolves aluminous earth. This ſolution affords, by evaporation, a yellowiſh maſs, tranſparent, ſoft, and aſtringent; which attracts moiſture from the atmoſphere, and reddens turnſol. This ſalt ſwells in the fire: it then loſes its acid, and the aluminous earth remains a little coloured. It is decompoſable by mineral acids.

In combination with barytes, it forms a ſcarce ſoluble ſalt; which, with an exceſs of the acid, affords angular cryſtals. Hot water, by depriving them of that exceſs, renders them opaque, pulverulent, and inſoluble.

With magneſia, it affords a white ſalt in powder, which is decompoſable by the fluoric acid and baryſes.

The oxalic acid, ſaturated with lime, forms a ſalt inſoluble in water, pulverulent, and not decompoſable by fire; for ſo ſtrong is the affinity between this acid and lime, that it detaches this baſe from every other acid. On account of this property, Bergman has propoſed the uſe of the oxalic acid for aſcertaining the preſence and the proportion of lime in mineral waters, or in any combination with other acids. Calcareous oxalate gives a green tinge to ſyrup of violets.

The oxalic acid combines with potaſh; and the neutral ſalt, with an exceſs of either of the two principles, is ſuſceptible of cryſtallization. Oxalate of potaſh is very

very ſoluble in water, and decompoſable by the action of fire and of mineral acids. Pure oxalic acid, added in drops to a ſolution of this ſalt, ſoon produces a precipitate, which appears to be oxalic acidulum, the ſame as the common *ſalt of ſorrel.*

With two thirds of ſoda, the oxalic acid forms a ſalt which is ſcarce ſoluble, but diſſolves beſt in hot water, and turns ſyrup of violets green. An exceſs of the acid forms acidulous oxalate of ſoda, which is ſcarce ſoluble.

With ammoniac, the oxalic acid affords ammoniacal oxalate, which cryſtallizes, by ſlow evaporation, into quadrilateral priſms. By fire, this ſalt is decompoſed; and then it yields ammoniacal carbonate, formed by the deſtruction of the oxalic acid. An exceſs of the acid poured into a ſolution of this ſalt, precipitates from it an ammoniacal oxalic acidulum, in cryſtals much leſs ſoluble in water than the pure neutral ſalt.

The oxalic acid is ſoluble in mineral acids. It imbrowns the concentrated ſulphuric acid; it is decompoſed by the nitrous acid, and reduced into carbonic acid in conſequence of the decompoſition. This acid generally combines much eaſier with metallic oxides than with the metals themſelves.

1. With oxide of arſenic, it forms priſmatic cryſtals, very fuſible, very volatile, and decompoſable by heat.

2. With oxide of cobalt, a pulveriſed ſalt, of a bright roſe-colour, and ſcarce ſoluble.

3. With oxide of biſmuth, a white ſalt in powder, very little ſoluble in water.

4.

4. With oxide of antimony, a ſalt in cryſtalline grains.

5. With oxide of nickel, a ſalt, of a white or greeniſh yellow colour, and ſcarce ſoluble.

6. With oxide of manganeſe, a ſalt in a white powder, which becomes black in the fire.

7. With zinc, the ſolution of which is attended with efferveſcence, a pulverulent white ſalt.

8. It diſſolves oxide of mercury, and reduces it to a white powder, which is rendered black by the contact of light. This acid decompoſes mercurial ſulphate and mercurial nitrate.

9. Tin, by its action, is firſt rendered black, and afterwards covered with a white powder. The ſalt which it forms with this metal is of an harſh taſte. It cryſtallizes into priſms, by evaporation judiciouſly conducted; when evaporated by an intenſe heat, it leaves a tranſparent maſs, reſembling horn.

10. It tarniſhes lead, but diſſolves its oxide better. The ſaturated liquor depoſites ſmall cryſtals, which may alſo be obtained by pouring oxalic acid into a ſolution of nitrate or muriate of lead, or into acetite of the ſame metal.

11. It acts on iron-filings; and as there is water decompoſed in this ſolution, there is of conſequence hydrogenous gas diſengaged. Oxalate of iron is ſtiptic: it affords greeniſh yellow priſmatic cryſtals, decompoſable by heat.

Yellowiſh oxide of iron, in combination with this acid, affords a yellow ſalt, ſimilar to that which is obtained by

by pouring liquid oxalic acid into a ſolution of ſulphate of iron.

12. It acts on copper, and entirely diſſolves the oxides of this metal. The ſalt thus formed is of a clear blue colour, and ſcarce ſoluble. This ſalt may be likewiſe obtained by precipitating ſulphuric, nitric, muriatic, and acetous ſolutions of copper, with oxalic acid.

13. Oxide of ſilver, precipitated by potaſh, diſſolves in a ſmall proportion in this acid. The beſt way of obtaining this ſalt is by precipitating the nitric ſolution of ſilver with oxalic acid: a white ſediment is produced, ſcarce ſoluble in water, and liable to become brown by the contact of light.

14. This acid ſcarce acts on oxide of gold.

15. Laſtly, it diſſolves the precipitate of platina produced with ſoda. This ſolution is ſomewhat yellow, and affords cryſtals of the ſame colour.

Such are the phænomena of the combinations of the oxalic acid, as deſcribed by Bergman.

That celebrated chemiſt accompliſhed all theſe combinations with artificial oxalic acid, prepared from ſugar and nitric acid. Sugar, as well as all mucilages, extracts, ſweet oils, and farina, affords, when treated with nitrous acid, an acid perfectly the ſame with pure oxalic acid, as has been aſcertained by Scheele. All theſe matters, and even a great many animal ſubſtances, as has been diſcovered by M. Berthollet, contain therefore the radical principle of the oxalic acid, wanting nothing but oxigene to complete the acid.

Bergman

Bergman was the firſt who diſcovered that ſugar, treated with nitrous acid, formed a peculiar acid: he gave it the name of the *acid of ſugar*, or *ſaccharine acid*; which it retained for ſeveral years, till Scheele ſhowed it to be preciſely of the ſame nature with the oxalic acid, extracted from *ſalt of ſorrel* by the proceſs above deſcribed. He ſhowed the identity of theſe acids, by forming the ſcarce ſoluble oxalic acidulum, or *ſalt of ſorrel*, from a combination of a ſmall quantity of ſoda, with the ſaccharine acid. Here, then, is a vegetable acid, which exiſts in an acid ſtate in but few vegetable matters, but of which the baſe is exceedingly copious in thoſe matters, and appears to paſs unaltered into animal bodies. In the following chapters, we ſhall ſee that this acid is probably, like all other vegetable acids, a compound of hydrogene, carbone, and oxigene; and that the only difference between it and the other vegetable acids is in the proportions of their principles.

The baſe or radical principle of the oxalic acid appears to exiſt in greater plenty in inſipid matters than in ſugar; though it was once believed, that ſaccharine bodies afforded moſt of it. From ſugar, Bergman obtained only a third part of its weight of oxalic acid: and from wool, M. Berthollet has obtained a quantity equal to more than half the weight of the wool.

The pure oxalic acid is uſed no where but in the laboratory; the chief uſe to which it is there applied, is to aſcertain the preſence of lime. The oxalic acidulum,

lum, or ſalt of ſorrel, is uſed to efface ſtains of ink from white ſtuffs, wood, ivory, &c. on account of its having ſo ſtrong an affinity with iron; but the pure oxalic acid being more ſoluble, might be more advantageouſly uſed for ſuch purpoſes.

CHAP.

CHAP. VII.

Of Vegetable Acids, formed by the Action of Fire, and by the Nitric Acid.

IT has been long known to chemiſts, that many vegetable matters afford, by diſtillation, phlegms, or acid liquors: theſe ſaline ſubſtances, altered by fire, were, however, but little attended to. Since ſuch a number of acids have been diſcovered, really diſtinct from one another, either in their intimate nature, or in the proportion of their principles, many of theſe ſalts have been found to poſſeſs peculiar and diſtinctive properties. It has been alſo aſcertained, that ſome acids act, like heat, on vegetable matters, and that the nitric acid, in particular, converts moſt of them into acid. Theſe new, or newly modified ſalts, need to be carefully examined, in order that we may acquire a knowledge of their nature. We cannot avoid remarking, in the firſt place, that there muſt be a general analogy of nature, or formation, among vegetable acids, produced by the action of heat: On account of that analogy, we give them the

the generic name of empyreumatic ſalts; and apply to each of them, as a ſpecific diſtinction, the ſyllable *pyro*, joined to a term indicating the origin of the ſalt; thus we ſay, the *pyro-tartareous*, the *pyro-mucous*, and the *pyro-ligneous* acids.

§ I. *Of the Pyro-Tartareous Acid.*

IT has been already mentioned, that, by the diſtillation of the tartareous acidulum, an acid phlegm is obtained, which is not the pure tartareous acid, but that acid altered in a particular manner. The hydrogenous gas, and the carbonic acid gas, that are at the ſame time diſengaged, ſhew plainly that ſuch an alteration muſt take place; for theſe can only be produced in conſequence of the decompoſition of the acid of tartar. As this alteration is owing to the action of heat, and as an oil, mixed with the diſtilled acid, is at the ſame time volatilized, which modifies its colour, we have therefore called that acid the *pyro-tartareous*, and its ſaline combinations *pyro-tartarites*, according to the laws of our nomenclature.

The firſt chemiſts who made experiments on this matter, with any degree of accuracy, aſcertained, that, by diſtilling about a quarter of a pound of tartar, there might be obtained an acid phlegm of a very pungent ſmell, or pyro-tartareous acid. The academicians of Dijon repreſent the ſecondary rectification or diſtillation of this acid, which has been recommended by ſo many authors, as attended with one very great difficulty:—notwithſtanding every precaution which they could

adopt to moderate the fire, and give room to the vapours, they always found the liquid to riſe ſo quickly as to burſt the veſſels containing it, into pieces. This phænomenon they attribute to the action of gas produced by the decompoſition of the acid, and compreſſed by the oil; which preſſure it at length overcomes, as it is more dilated. Beſides, the rectification is not very neceſſary, as the acid ſeparated from the oil by the ſtill-pipe is ſo pure as to exhibit all its diſtinctive characteriſtics.

The pyro-tartareous acid has an empyreumatic taſte and ſmell. It does not redden ſyrup of violets, but it produces that effect on turnſol and blue paper: It diſengages the carbonic acid from its baſes with a lively efferveſcence. With the earths and alkalis, it forms ſalts very different from thoſe which the tartareous acid forms with the ſame baſes. Theſe ſaline compounds have not yet been examined; only we know the pyro-tartarites of potaſh and ſoda, to be ſoluble in cold water, and cryſtallizable: the acid decompoſes nitrate of ſilver, producing from it a grey precipitate; it by degrees renders nitrate of mercury turbid; it does not decompoſe calcareous muriate; and the ſulphuric acid decompoſes its neutral ſalts by diſtillation.

Chemiſts, before hydrogene, carbonaceous matter, and oxigene, were underſtood to be the ſole and genuine component principles of all vegetable acids, conſtituting different acids only by being united in different proportions, had adopted opinions very remote from the truth, concerning the nature of this acid, obtained by diſtillation from tartar. Venel aſſerted it to be acid of

nitre,

nitre. M. Monnet concluded, from a more accurate inveſtigation of its nature, that it was muriatic acid diſguiſed by oil and mucilage. But although Scheele found tartar to contain a little muriatic acid, yet the cubic form of the neutral ſalt, produced by the union of the pyro-tartareous acid with ſoda, and the precipitation of nitrate of mercury by this acid, the two facts on which M. Monnet eſtabliſhes the identity of the pyro-tartareous with the muriatic acid, are not ſufficient evidence to induce modern chemiſts to aſſent to the concluſion deduced from them. Beſides, the chemiſts of Dijon have repeated the ſame experiments without obtaining the ſame reſults; nor have Meſſrs Berthollet, Spielman, and Corvinus, been more ſucceſsful. On the contrary, it is highly probable, that the principles of the pyro-tartareous acid are the ſame with thoſe of the acid of tartar itſelf; and that the two acids differ only in the proportion of their principles: the ſmell and taſte of this empyreumatic acid, its not being ſuſceptible of cryſtallization, and all its other properties, and ſtill more the diſengagement of oil and carbonic gas from the tartareous acidulum, when the pyro-tartareous acid is formed,—concur to prove the truth of what is here aſſerted.

The character of this empyreumatic acid has not yet been ſufficiently inveſtigated, to enable us to determine the order of its chemical affinities with earthy, alkaline, and metallic baſes.

§ II. *Of the Pyro-Mucous Acid.*

THE acid which we denominate pyro-mucous, is that obtained from inſipid, ſaccharine, gummy, farinaceous, &c. mucilages, which was at firſt denominated by M. de Morveau the ſyrupous acid. Chemiſts have long known that ſugar affords, by diſtillation, a pretty ſtrong acid phlegm. Neuman, Cartheuſer, Geoffroy, and Bucquet, have made particular mention of that acid, but without having examined its properties. M. Schrickel has examined its nature with more minute attention than any other chemiſt.

By diſtilling 16 ounces of ſugar, M. Schrickel obtained 6 drachms of phlegm, which paſſed into the receiver in the form of white vapour, and was condenſed into unctuous ſtriæ, of a pungent ſmell, like that of horſe-raddiſh, or bitter almonds, roaſted; of an acid, acrid, and bitter taſte, and of a red yellow colour. He rectified this acid upon clay; it then paſſed clear, with a leſs pungent ſmell, and a ſour taſte. This acid, when thus puriſied, did not cryſtallize; but when expoſed to cold, the aqueous part froze, and that part which ſtill remained liquid, became much more concentrated.

M. de Morveau obſerved, when preparing the pyro-mucous acid by the diſtillation of ſugar, that the bottom of the retort was corroded during the operation. He does not attribute this to the acid, as it exhibits no ſuch property when rectified, or when left long in the glaſs; but rather to the action and adheſion of the carbure of iron, which exiſts in the coal that remains after the decompoſition of the ſugar, and had been violently heated. This acid, therefore, cannot be concentrated

by volatilizing the water that is united with it, as the ſalt is no leſs volatile than the fluid. This acid, according to M. de Morveau, exiſts in molaſſes, and renders them deliqueſcent, and not ſuſceptible of cryſtallization.

The pyro-mucous acid, when concentrated by freezing, is very pungent, and communicates a deep red to blue vegetable colours. It produces red ſpots on the ſkin, as was long ago obſerved by Cartheuſer; and the ſpots thus produced deſtroy the epidermis before they diſappear. When expoſed to fire, it is totally volatilized, leaving no reſidue but a brown mark on the place where it lay. Moſt of it may be converted into carbonic acid gas, and hydrogenous gas, by diſtilling it, with proper precautions, in cloſe veſſels: it now affords a more copious carbonaceous reſidue than when heated in open veſſels. A part is volatilized without alteration.

When combined with barytes, magneſia, lime, potaſh, ſoda, and ammoniac, it forms neutral ſalts, which we call *pyro-mucites*, the properties of which have not yet been examined with ſufficient care, but which differ from all other known neutral ſalts. It diſengages the carbonic acid from all of theſe alkaline baſes with a lively effervescence.

The property of diſſolving gold was formerly aſcribed to the ſpirit of honey; but it appears for certain, that the pyro-mucous acid does not affect either that metal, or platina, or ſilver, or even mercury; but it might poſſibly diſſolve the oxides of theſe metals. This acid corrodes lead, becoming opaque itſelf on the occaſion; which alteration it owes to the oxide of lead which it

forms. Pyro-mucite of lead is in oblong cryſtals. It acts upon copper, and becomes green by the re-action of that metal; it diſſolves tin; it acts upon iron, and combines with that metal to form cryſtals.

Its chemical affinities have been determined by M. de Morveau in the following order; Potaſh, ſoda, barytes, lime, magneſia, ammoniac, aluminous earth, metallic oxides, water, alcohol.

This empyreumatic acid has not as yet been applied to any purpoſe. Spirit of honey, of manna, &c. were formerly made uſe of in pharmacy; but the uſe of them has been long given up.

§ III. *Of the Pyro-ligneous Acid.*

WOOD, eſpecially beech, birch, and box trees, afford, by diſtillation, a brown acid liquor, of a pretty ſtrong, peculiar ſmell, which reddens blue vegetable colours, and effervesces with alkaline carbonates. Boerhaave was acquainted with the product of box, juniper, oak, and *Guayac*: but the chemiſts who have repeated Boerhaave's proceſs, have not examined the nature and peculiar properties of this acid. M. Goettling, in the year 1779, firſt publiſhed, in Crell's Journal, a Memoir on the acid of wood, and more eſpecially on its union with alcohol. That chemiſt diſtilled the bark of birch in an iron retort: he obtained a brown, oily, acid product, which he left to ſettle for three months; at the end of that time, he obſerved drops of oil ſwimming on its ſurface, which having ſeparated by filtration, he poured into the filtrated liquor a ſolution of potaſh. A lively

lively effervescence took place; the liquor assumed a blood-red colour, and afforded, after being saturated with alkali, and evaporated, a black salt, which was melted in an iron pan, and purified by a second solution, and a second evaporation.

The pyro-ligneous acid may be also rectified by distillation, according to M. Goettling. The pyro-lignite of potash, formed of this rectified acid, becomes very hot when brought into contact with the sulphuric acid, and affords pyro-ligneous acid in a state of considerable purity. That chemist, to whom we are indebted for these facts, observes, that the pyro-ligneous acid, when separated by the sulphuric acid, has no longer any empyreumatic odour, but a smell of garlic.

The chemists of Dijon extracted this acid from beech, by distillation, and afterwards rectified the liquid product: 55 ounces of this wood, well dried, and in shavings, afforded 17 ounces of rectified acid, of an amber-colour, not mixed with oil, and of which the gravity was to that of distilled water, in the proportion of 49 to 48: $23\frac{1}{2}$ ounces of lime-water were required to saturate an ounce of this acid. When exposed to a gentle heat, it ascends in vapour. A strong heat decomposes this, as well as all other vegetable acids. It cannot be obtained in a concrete form.

It combines with earthy and alkaline bases, and forms with them peculiar salts, which we call pyro-lignites of alumines, barytes, magnesia, lime, potash, soda, and ammoniac. These salts have not yet been examined with sufficient care to enable us to give here a particular account of them. M. Eloy Bourfier de Clervaux has communicated, in the Lectures of Che-

miſtry of Dijon, ſome experiments very ſuitable to determine the elective attractions of the pyro-ligneous acid. Calcareous and barytic earths adhere to it with greater obſtinacy than the alkalis; lime has a ſtronger affinity with it than barytes; and magneſia a ſtronger than ammoniac: and even theſe affinities may ſerve to diſtinguiſh it from moſt other vegetable acids. It acts alſo upon many of the metals, and diſſolves moſt of their oxides.

All kinds of wood, it appears, would afford the ſame acid by diſtillation; for box, birch, and beech, agree in affording one acid. But much inquiry, and many experiments, are neceſſary, before we can be fully acquainted with the characteriſtic properties of this acid.

§ IV. *Of Vegetable Acids, formed by the Nitric Acid.*

BERGMAN has proved, that the nitric acid converts ſugar into an acid, which, being at firſt thought peculiar and different from all others, was therefore called the ſaccharine acid. Scheele has ſhown this ſalt to be preciſely the ſame with that which is in part neutralized by potaſh, in ſalt of ſorrel: this very ſalt is therefore in every reſpect the ſame with the oxalic acid. Several modern chemiſts, and eſpecially M. Berthollet, have proved, that almoſt all animal and vegetable matters afford this acid, when treated with the acid of nitre. It is therefore certain, that the baſe or radical principle of the oxalic acid exiſts in a great many bodies, and, in general, in all bodies which have been formed by vegetation, or the functions of animal life. The nitric acid acts in an equal and uniform manner on all ſuch ſubſtances;

ſtances; it always gives up to them either more or leſs of its oxigene, and paſſes into the ſtate of nitrous acid, nitrous gas, or even azotic gas, according as it is deprived of a greater or a leſs proportion of its oxigene. As the baſe, or radical principle of the oxalic acid, is more or leſs copious in the various organic matters in which it is found; theſe matters afford more or leſs of this acid, when treated with nitric acid. At the ſame time, when the acid of nitre is decompoſed by organic ſubſtances, together with nitrous or azotic gas, there is alſo diſengaged a certain quantity of carbonic acid gas, which proves the organic matter to have loſt a part of its carbonaceous ſubſtance, and at the ſame time ſhews the oxalic acid, thus produced, to contain leſs of that principle than the ſubſtance from which it is obtained. Since a number of vegetable acids, particularly the tartareous acid, &c. paſs into the ſtate of oxalic acid, in conſequence of being expoſed to the action of nitrous acid; and ſince carbonic acid is diſengaged while this change takes place; it follows plainly, therefore, that all the vegetable acids have the ſame radical principle, and differ only in their proportions of oxigene.

In the *Nouvelles de la Republique de Lettres* for the year 1785, No. 42. and 44. it was related, that M. Koſegarten, by diſtilling nitric acid on camphor, eight times ſucceſſively, had obtained from that matter a concrete acid, in parallelipiped cryſtals, of bitter taſte, and capable of reddening the tincture of violets and turnſol. That ſalt, according to this chemiſt, differs from oxalic acid, as being incapable of ſeparating lime from the muriatic acid. With potaſh, it forms a ſalt in regular hexagons; with ſoda, a ſalt in irregular cryſtals; with ammoniac,

ammoniac, priſmatic, or needled cryſtals; with magneſia, a ſoluble, pulverulent ſalt. It diſſolves copper, iron, biſmuth, zinc, arſenic, and cobalt. But theſe facts, which have not yet received confirmation, are not ſufficient to enable us to enter into a minute account of the properties of this acid, which is, perhaps, nothing but a particular modification of ſome one of thoſe of which we have already ſpoken. And if farther experiments on this acid ſhall diſcover it to poſſeſs peculiar properties, different from thoſe of the other acids, its nature and characteriſtic properties muſt then be examined under the name of the camphoric acid, and its neutral ſalts will be called *camphorates*.

M. Brugnatelli diſcovered, in the year 1787, that cork, on which he diſtilled four times its own weight of nitrous acid, left a yellowiſh maſs, thick, acid, ſoluble in water, and of a ſour, or rather a bitter taſte. This acid is not ſuſceptible of cryſtallization; when evaporated by a ſtrong heat, it takes the form of a viſcous maſs, like wax, which is ſo ſoft that it may be moulded with the fingers. It is ſoluble in alcohol; on burning coals, it is reduced to a coal without inflammation; with earths and alkalis, it forms deliqueſcent ſalts, many of which cryſtallize: laſtly, it has as ſtrong an affinity with lime as the oxalic acid, and forms with that earth a ſalt that is not ſoluble in water, but may be diſſolved in muriatic acid. Without preſuming to ſpeak deciſively of the peculiar nature of this acid, M. Brugnatelli appears, however, to think it different from the oxalic acid. Future experiments muſt determine whether this be really a peculiar acid meriting a ſeparate examination; and we muſt, in the ſame manner, leave the particular nature

of

of that which has been diſcovered by Meſſrs Prouſt and Angulo, in the neighbourhood of Madrid, on the ſurfaces of grey peaſe, in veſiculæ at the extremity of the hairs of that leguminous plant, equally undetermined.

Thus we have given an account of all known vegetable acids. We have ſtill, however, to treat of thoſe which are formed by fermentation. But as the chief, nay, the only one of theſe acids that is known, is produced in conſequence of an alteration taking place on liquors that are already fermented, we will give its hiſtory immediately after that of ſpirituous fermentation, and its product.

CHAP.

CHAP. VIII.

Of Saccharine Matter, Gums, and Mucilages.

THE ſaccharine matter, which many chemiſts think to be a ſort of eſſential ſalt, is found in a great many vegetables, and is to be conſidered as one of their immediate principles.—The maple, the birch, the red beet, the parſnip, the grape, wheat, &c. are found to contain it. Margraff extracted it from moſt of theſe vegetables. The petals of many flowers, and the nectaria placed in thoſe organs, prepare a principle of this kind.

The ſugar-cane, *arundo ſaccharifera*, is the plant which contains the moſt of it, and from which it is extracted with the greateſt advantage. The ſugar-canes are cruſhed to pieces between two iron cylinders, in a perpendicular poſition. The expreſſed juice falls upon a plain ſurface underneath; and is called *melaſſes*. It runs off this ſurface into a boiler with aſhes and lime, where it is boiled and ſkimmed; and, in the ſame manner, it is ſucceſſively boiled and ſkimmed in three other boilers; and, after undergoing theſe boilings, it receives the name

name of syrup. It is after this boiled anew, by a strong heat, and for a considerable time, with lime and alum. After being sufficiently boiled and concentrated, it is poured into a vessel called *the cooler*. When it is so cool that the finger may be dipped in it without injury, it is poured into large barrels standing over cisterns, and the bottoms of which are perforated with holes stopped with canes. In the barrels, the syrup takes the form of a solid mass, part of it running off into the cisterns. The sugar, when thus rendered concrete, is yellow and unctuous; it is now called *muscovado*. In the sugar-islands, it is refined by boiling it, and then pouring it fluid into inverted cones of earthen ware, called pans. That part which cannot be rendered concrete runs through a hole in each of the pans, into a pot placed below; it is called *coarse syrup*. The base of the sugar-loaf is taken away, and white sugar in powder put into its place, and pressed well down: The whole is then covered with pure moist clay. The water of the clay filtrates through the sugar, carrying off with it a portion of the mother-water of the sugar, which runs out by the holes in the pans, and is received into new pots. This is called *fine syrup*, as being purer than the former. A second layer of clay is laid on when the first becomes dry, and the water filtrates through, a second time: When the water contained in the second layer of clay is drained off, the loaves are removed into a stove to dry. At the end of eight or ten days these loaves are broken, and sent into Europe in the form of brown sugar, which is here refined into sugar of different qualities.

The refining of sugar is accomplished by boiling it in lime-water,

lime-water, and with bullock's blood, ſkimming it two or three times, filtrating the liquor, and running it in pans, to give it the ſhape of loaves. Theſe loaves are then coated over with wet clay, the water of which is ſuffered to filtrate through them. The filtration is repeated with freſh clay, till the ſugar become ſufficiently white. The loaves are then removed into a ſtove, and at the end of eight days are wrapped up in a paper for ſale. The *ſyrup* which cannot be cryſtallized is called *molaſſes*.

Chemiſts have univerſally been of opinion, that theſe different operations ſeparated from ſugar a fat matter, and thereby rendered it ſuſceptible of cryſtallization. Bergman thinks, that the uſe which the lime ſerves is, to carry off the exceſs of acid, which hinders it from taking a ſolid form. The acid can be no other than the pyro-mucous acid which is formed by heat, as we have related in the foregoing chapter. As the liquor is expoſed, during the operation, to a violent evaporation, it becomes a granulated, irregular maſs, agreeably to what has been already obſerved of ſulphate of zinc.

Sugar is a ſubſtance in ſome meaſure of an intermediate nature between eſſential ſalts and mucilages. It cryſtallizes in truncated hexahædral priſms. In this ſtate it is called *ſugar-candy*. It affords, by diſtillation, water, pyro-mucous acid, and a few drops of empyreumatic oil. There is at the ſame time diſengaged from it a conſiderable quantity of carbonic acid gas, and of hydrogenous gas, with coal diſſolved in it. The reſidue is a ſpongy light coal, containing a little carbonate of potaſh.

Sugar is inflammable: When laid on burning coals, it melts and ſwells; it exhales a very pungent acid vapour;

pour; it takes a brown-yellow colour, in conſequence of which it recieves the name of *caramel.* It diſſolves very readily in water. It communicates to it a conſiderable conſiſtency, forming with it a ſort of ſaccharine mucilage, which has received the name of *ſyrup.* This ſyrup, when diluted in water, is ſuſceptible of fermentation; it may even be converted into a vinous liquor, and alcohol diſtilled from it.

Bergman prepared from all the different ſaccharine matters, eſpecially from ſugar,—oxalic acid, by means of the nitric acid. To obtain that acid from theſe matters, put into a retort one part of ſugar in powder, with ſix of nitric acid: Expoſe the mixture to a moderate heat; continue the evaporation for ſome time after red vapours ceaſe to paſs; leave the ſolution to cool; and it then precipitates white needled or priſmatic cryſtals, which are concrete oxalic acid.

Sugar is very much uſed.—It is an article of food, which, when taken in too large a quantity, heats the animal ſyſtem. It is much uſed in pharmacy, being the baſis of ſyrups, lozenges, and ſome other preparations. It contributes to diſſolve and ſuſpend in water, reſins, oils, &c. It ſerves to preſerve fruits reduced to jelly. It may be even conſidered as a medicine; for it is inciſive, aperitive, and, in a ſlight degree, tonic and ſtimulant: And accordingly there are ſome inſtances related, in which diſorders ariſing from obſtructions have been cured by the continued uſe of ſugar.

There are ſome juices of plants which have a taſte of ſugar. Manna and nectar are of this kind. Manna is obtained from the leaves of fir, oak, juniper, &c. and maple-trees, &c. The aſh, which is very plenteous in Calabria

Calabria and Sicily, affords that which is commonly ſold. It runs naturally from thoſe trees, but is obtained in ſtill greater abundance by making notches in the bark of the tree.—That which is received on chips of wood, or ſmall ſticks introduced into artificial apertures in the trees, takes the form of hollow ſtalactites, and is called *manna in tears*. *Manna in flakes* runs down the bark, and contains ſome impurities. The inferior unctuous ſort contains many extraneous matters, and is formed from the refuſe pieces of the two former. It is always humid, and frequently altered. The taſte of manna is mild and inſipid: That which the larch-tree that abounds in Dauphiny affords, and that of the alhagi, which grows in Perſia, around Mount Tauris, are not in uſe; the latter bears the name of *tereniabin*.—Manna is ſoluble in water; it affords, by diſtillation, the ſame products as ſugar. There is extracted from it, by means of lime and white of eggs, a matter reſembling ſugar, which, when treated with the nitric acid, affords concrete oxalic acid.

It is given as a purgative, in dozes of from one to two or three ounces; or, when it is given as a diſcuſſive, a few drachms of it are diluted in a large proportion of water.

Another ſort of proper juice is that called *gum* or *mucilage*. This ſubſtance is very plenteous in the vegetable kingdom. It is found in a great many roots: Young ſtems and leaves, immediately after their appearance, contain a good deal of it. This principle may be known by its viſcous adheſive property. In the ſeaſon when the juice is moſt copious, it runs naturally down the bark of trees, and thickens into gum on the ſurface.

The

The gum is ſoluble in water, to which it communicates a thick viſcid conſiſtency. This ſolution, known by the name of *mucilage*, becomes, when evaporated, dry, tranſparent, and friable.

Gum burns without emitting any perceptible flame. It melts and ſwells upon coals. It affords, by diſtillation, a good deal of water and pyro-mucous acid, a little thick brown oil, and carbonic acid gas, mixed with hydrogenous gas: The reſidual coal is very bulky, and contains a little carbonate of potaſh.

We know of three ſorts of gum that are uſed in medicine, and in the arts.

1. The gum of the apricot, the pear, and the plum tree, &c. It is either white, yellow, or reddiſh; the beſt of this ſort of gum may be applied to the ſame purpoſes as the other gums. A kind of gummy juice, of a beautiful orange-colour, flows from the elm; conſiderable quantities of it are ſometimes found on the bark of the tree. I have found this gum to poſſeſs the properties of inſipidity, inſolubility, viſcidity, with the other characteriſtics belonging to ſuch juices.

2. Gum Arabic, which runs from the acacia in Egypt and Arabia. Gum Senegal is of the ſame kind; it is uſed in medicine as a mitigating and relaxing remedy. Crayons, and ſome other ſuch compoſitions, are indebted to it for their conſiſtency. It is uſed in various arts.

3. Gum Adraganth, which flows from the adraganth of Crete; Aſtragalis Tragacantha. It is adminiſtered in the ſame caſes as Gum Arabic; the ſolution of it is ſomewhat thicker than the ſolution of Gum Arabic; it ſoon

depoſites viſcid flakes, and requires more water to diſſolve it.

Mucilages, of the ſame nature with gums, are obtained from various plants. The roots of mallows, marſh-mallows, the greater comfrey, the bark of elm, lintſeed, the ſeeds of quinces, &c. afford, by maceration in water, viſcous fluids; which, when evaporated to dryneſs, afford real gums. In medicine, decoctions of theſe plants are uſed inſtead of ſolutions of gums.

All of theſe matters, chemically conſidered, appear at firſt view to be nearly ſimple bodies; for chemical operations often offer to our obſervation ſubſtances of a gelatinous form, much like that of gums and mucilages; yet, from theſe products of vegetation, which appear to form a ſort of excrementitious humour, are extracted water, liquid pyro-mucous acid, carbonic acid, an oily principle, and fixed alkali united to a coaly reſidue. This reſidue likewiſe contains a fixed earth, the nature of which is ſtill unknown.

When mucilages and gums are treated with nitric acid, and its action aſſiſted by heat, they afford oxalic acid in cryſtals. They contain therefore the oily or radical principle, which, in combination with oxigene, conſtitutes this acid.

This analogy between mucilage and ſaccharine matter is farther obſervable in that the ſmell of burnt gum is much the ſame with that of caramel—that the products which both afford by diſtillation are of a ſimilar nature—and that the bulk and levity of the reſidual coal are the ſame in both. Some of thoſe fruits which become ſaccharine, ſuch as apricots, pears, &c. exſude, before they become ripe, a real gum. That ſort of dry mucilage which

we

we are hereafter to examine under the name of *amylaceous fecula*, ſeems to be converted into ſaccharine matter by germination. Theſe facts, and many others which might be joined with theſe, ſhew that there is a near relation between ſugar and gum. Perhaps the inſipid or gummy mucilage paſſes by a ſort of fermentation into the ſtate of a ſaccharine body. Were this an aſcertained fact, this fermentation would come in order before that which Boerhaave has called *ſpirituous fermentation*; and muſt conſtantly precede it, both in the natural proceſs of vegetation, and in the operations which art employs to produce the ſaccharine taſte in barley, &c.

CHAP. IX.

Of Oils of a fixed Nature, that are extracted by Expreſſion.

OILS are proper juices, of a fat, unctuous nature, either fluid or ſolid, not ſoluble in water; liable to burn with flame, volatile in various degrees: They are contained in the proper veſſels, or in particular veſiculæ. Theſe bodies are found exiſting in two ſtates in vegetables: They are either combined with other principles, as in extracts, mucilage, &c. or they are free, and not united with any other principle. Theſe latter oily juices are thoſe of which we are here to ſpeak.

Chemiſts have ſuppoſed the exiſtence of a ſimple oily principle, as well as of a primitive ſalt. This oily principle, combined with different ſubſtances, and modified by thoſe combinations, conſtituted, according to them, the various ſorts of oils that were obtained by analyſing vegetables. The characters which they aſcribed to that ſimple primitive oil, were, great fluidity, an high degree of volatility, privation of colour and ſmell:—It burnt

with

with flame and ſmoke;—It did not combine with water: —It was thought to conſiſt of water and an acid combined with an earth and *phlogiſton*. It is certain that oils, when decompoſed, always afford a ſmall quantity of acid, and a good deal of hydrogenous gas: earth conſtitutes but a very ſmall part of them, for they leave but very little fixed carbonaceous reſidue. This notion of the oily principle deſerves to be viewed only in the light of an hypotheſis.

Oils are never formed by any but organic beings; and ſuch bodies in the mineral kingdom as are of an oily nature, always owe their origin to the action of vegetable or animal life. It is even highly probable, that vegetables are the only bodies in which oils are formed; and that they paſs without alteration from vegetable into animal bodies.

The oily juices of vegetables are diſtinguiſhed into fixed oils and volatile oils.

Fixed oils, called alſo *fat oils*, *ſweet oils*, *oils by expreſſion*, are very unctuous: they have generally a mild and inſipid taſte, and no ſmell; the heat requiſite to volatilize them is above that of boiling water; and they never take fire till they are brought to that degree of heat which is requiſite to volatilize them.—It is for this purpoſe the wick uſed in burning fixed oil in lamps is employed; it heats the oil to volatilization.

Moſt fixed oils are fluid, and require no conſiderable degree of cold to render them ſolid: Others, again, loſe their fluidity by the ſlighteſt cold; and, laſtly, there are others always ſolid: Theſe laſt are called, but very improperly, *vegetable butters*.

Fixed oils never flow from the ſurfaces of vegetables: They are contained in the kernels, the pippins, and emulſive ſeeds. They are extracted by bruiſing the little cells in which they are contained; that is, by pounding and ſqueezing.

Fixed oils, when expoſed to the air, are altered, and become rancid; their acid is liberated; they loſe the properties which they poſſeſſed, and acquire others, in conſequence of which they are nearly aſſimilated to volatile oils. Water and alcohol carry off the acid, and thus deſtroy their rank taſte, but never reſtore them to their primary ſtate. M. Berthollet has diſcovered, that fat oils, when expoſed to air, by being thinly ſpread over the ſurface of water, become thick, and aſſume pretty much the ſame appearance with wax. It is at preſent known as an undeniable fact, that this thickening of oils is owing to their abſorbing oxigene from the atmoſphere; for all ſubſtances that contain this principle, and reſign it to fixed oils,—as for inſtance, many of the acids, eſpecially the oxigenated muriatic acid, and metallic oxides, —thicken fixed oils, and reduce them to a ſtate in which they reſemble wax.

Fixed oils afford by diſtillation a little water, containing a very acrid pungent acid, ſome light oil, a thick oil, and a large quantity of hydrogenous gas, mixed with carbonic acid: They leave but very little reſidual coal. By diſtilling theſe products a ſecond time, pure ſebacic acid is obtained, of which we will have occaſion to ſpeak in the animal kingdom, and ſome oil, ſtill lighter than what was before obtained.—This oil is improperly called *philoſophers oil.* The alchemiſts prepared it by diſtilling ſeveral times ſucceſſively, a brick impregnated with fixed oil.

oil. It is not perfectly known how far this decompoſition may be carried: formerly, indeed, it was ſaid that a fixed oil might be reduced to a free inflammable principle; into water, acid, air, and earth.

Cold water effects no alteration on fat oils; it purifies them by carrying off a part of their mucilage, which is likewiſe precipitated when they are ſubmitted to combuſtion, and is the principle that renders them ſuſceptible of fermentation, and liable to become rancid.—It is well known, that water caſt upon theſe oils, when burning, inſtead of quenching, cauſes them to burn with new violence: the reaſon of which is, that the water, being decompoſed, ſupplies oxigene to the oil, and at the ſame time gives out a good deal of hydrogenous gas. When the vapour which proceeds from fixed oil in combuſtion, is collected into a chimney terminating in a worm-pipe, a conſiderable quantity of water is obtained; which proves this immediate principle of vegetables to contain hydrogene.

Fixed oils do not combine with ſiliceous earth: With clay, they form a ſoft paſte, which is employed in chemical manipulations, under the name of *fat lute*.

They combine, by particular proceſſes, with magneſia, and are thereby reduced to a ſaponaceous ſtate.

Lime combines with them, but not in a very diſcernible manner, when the combination is immediate. Pure alkalis combine eaſily with fat oils, producing by this combination what is called *ſoap*.

In making ſoap, oil of olives or ſweet almonds is triturated with a concentrated lixivium of ſoda, rendered cauſtic by lime; and this preparation is known by the name of *ſoap-lye*.—In the courſe of a few days, the mix-

ture becomes thick, and forms medicinal ſoap. Common ſoap is prepared by boiling the lixivium with altered oil; it is then white. Green ſoap is made up of the refuſe of olives and potaſh.

Soap diſſolves in pure water: Heat decompoſes it, diſengaging from it phlegm, oil, and ammoniac, formed in conſequence of the decompoſition of the fixed alkali and the oil; the coaly reſidue contains a good deal of fixed alkali. This artificial compoſition of ammoniac ſeems to prove, that there is azote in the fixed alkali, which re-acts upon the hydrogene of the oil.

Lime-water decompoſes ſoap, as has been remarked by M. Thouvenel; an inſoluble calcareous ſoap is then formed, and depoſited in ſmall lumps. Acids, poured on ſoap, diſengage the oil, ſomewhat altered.

Ammoniac does not eaſily combine with fixed oils: however, by long trituration, the mixture acquires ſome degree of conſiſtency, and becomes opaque.

Fixed oils combine with weak acids to form peculiar ſoaps. Meſſrs Achard, Cornette, and Macquer, have examined theſe compounds. M. Achard formed them by pouring ſlowly a quantity of concentrated ſulphuric acid upon the fixed oil. By continued trituration, this mixture is formed into a brown maſs, ſoluble in water and alcohol. The oil obtained from it by the intervention of alkalis, is always more or leſs concrete, as well as that obtained by diſtillation. Macquer adviſes to prepare this ſoap by pouring acid on the oil; but he informs us, that an acid ſoap, formed in this manner, is ſcarce ſoluble in water; that which is prepared of concentrated ſulphuric acid, triturated with common alkaline ſoap, is more ſoluble. The concentrated ſulphuric

phuric acid blackens fixed oils, and aſſimilates them to bitumens. This phenomenon ſeems to be produced by the re-action of the hydrogene of the oil on the oxigene of the acid.

The fuming nitrous acid blackens fixed oils inſtantaneouſly, and cauſes ſuch as are of a dry nature to kindle and emit a flame. Thoſe, again, which cannot be ſo readily dried, require to kindle them a mixture of this acid with the acid of ſulphur, as has been ſhown by Rouelle the elder, in his Memoir on the Inflammation of Oils. *Academy, year* 1747.

The muriatic and the carbonic acids act with but little ſtrength on fixed oils.—The former of theſe, however, in a concentrated ſtate, combines with them to a certain degree, according to M. Cornette. The oxigenated muriatic acid thickens them a good deal, and ſeems to make them paſs, by the abſorption of its oxigene, into a ſtate in which they bear a great reſemblance to wax.

We know nothing of the action of the other acids on fixed oils. It appears that they do not combine with neutral ſalts. Several of theſe, and eſpecially all calcareous ſalts, decompoſe alkaline ſoap. In this inſtance of decompoſition, particularly when ſulphate of lime, or of magneſia, which is often found in union with waters, decompoſes this ſoap, the ſulphuric acid combines with the fixed alkali of the ſoap, and thereby forms ſulphate of ſoda; the lime or magneſia combines with the oil, and produces a ſort of ſoap that is ſcarce ſoluble, and ſwims in whitiſh lumps on the ſurface of the water. This is the cauſe of the common appearance produced by hard waters, which curdle ſoap, but do not diſſolve it.

The

The action of hydrogenous gas on fixed oils has not yet been examined.

Theſe oils diſſolve ſulphur, when their action is aſſiſted by a boiling heat. The ſolution is of a dark red colour, inclining to brown. It has a very fœtid ſmell. It depoſites, by degrees, ſulphur in cryſtals. On diſtilling this combination, the ſulphur is volatilized, being ſo completely diſſolved in the hydrogenous gas that is diſengaged from the oil, that not an atom of it is to be afterwards found. This fact deſerves to be more particularly inquired into. There is alſo a little ſulphureous gas obtained by this decompoſition.

Fixed oils ſeem not to be ſuſceptible of combination with pure metallic ſubſtances, excepting iron and copper, upon which they act in a ſufficiently diſtinct manner. But they combine with metallic oxides, and form with them thick concrete combinations, of a ſoapy appearance, as is obſervable in the preparation of unguents and plaſters. Theſe preparations have not been yet chemically examined: only we know, that ſome metallic oxides are reduced in the making up of plaſters; as, for inſtance, oxide of copper in the Divine Plaſter, and litharge, or oxide of lead, in the ointment *de la mere*. In the aſſaying of metals, fixed oils are employed to reduce the metallic oxides. M. Berthollet has given an ingenious and ſimple proceſs for effecting inſtantaneouſly a real combination between fixed oil and any metallic oxide, that is, for preparing a metallic ſoap. It conſiſts in pouring a metallic ſolution into a ſolution of common ſoap. The acid of the metallic ſolution combines with the fixed alkali of the ſoap; and the metallic oxide is then precipitated in union with the oil, to which it

communicates a colour. In this manner, ſoap of a beautiful green colour may be prepared with ſulphate of copper; and with ſulphate of iron, a clear deep brown ſoap. Theſe compounds might be very uſeful in painting.

Scheele has diſcovered, that when oil of ſweet almonds, olives, rapeſeed, or lintſeed, is combined with oxide of lead, with the addition of a little water, there is a matter ſeparated from the oil, which ſwims on the ſurface of the liquor, and to which he has given the name of *the mild principle.* On evaporating this ſupernatant water, the principle diſſolved in it cauſes it to take the conſiſtency of ſyrup; when expoſed to a ſtrong heat, it takes fire: one part is volatilized, in diſtillation, without burning: the coal which it leaves is light: it does not cryſtallize; nor does it ſeem to be ſuſceptible of fermentation. Nitric acid diſtilled on this matter, four times ſucceſſively, changes it into oxalic acid. This mild principle of Scheele's appears to be a ſort of mucilage.

Fixed oils diſſolve bitumens, particularly amber; but they muſt be aſſiſted by the action of heat, in order to effect this ſolution. They form a ſort of greaſy varniſh, which does not readily become dry.

Fat oils may be diſtinguiſhed into three genera:

To the *firſt* claſs belong ſuch pure fixed oils as are fixed by cold, are ſlowly thickened, form ſoaps with acids, and are kindled only by a mixture of the acids of ſulphur and of nitre. Such are,

1. Oil of olives, obtained by bruiſing that fruit between two millſtones, and preſſing it in bags made of ruſhes. That which runs firſt is called *virgin oil*; that which

which is obtained from mark ſprinkled with water is not ſo pure, and depoſites a lee; that obtained from unripe olives, is the *oleum omphacinum* of the ancients. Oil of olives freezes at 10° degrees under Zero in Reaumur's thermometer, or 10½ above that point in Fahrenheit's, and will ſtand about twelve years without becoming rancid.

2. Oil of ſweet almonds, extracted without the application of heat, becomes very ſoon rancid: it freezes at 6° under ☌ in Reaumur's ſcale, or 17½ of Fahrenheit's.

3. Oil of rapſeed, obtained from the ſeed of a kind of cabbage called *colſa*.

4. Oil of ben, extracted from the ben-nut of Egypt and Arabia. It is very acrid, and deſtitute of ſmell. It freezes very eaſily.

The ſecond genus comprehends oils ſubject to become dry, which are very eaſily rendered thick, are not fixed by the action of cold, are kindled by the nitrous acid alone, and form, with ſulphuric acid, a ſort of reſin. Such are,

1. Lintſeed-oil, obtained by preſſure from lintſeed roaſted. It is uſed for oily varniſhes, and in painting.

2. Oil of nuts, applied to the ſame uſes.

3. Oil of carnations, or poppy ſeed; which, as has been fully proved by the Abbé Rozier, is not at all narcotic.

4. Oil of hempſeed, which is very drying.

Under the third genus, we comprehend concrete fixed oils, or *vegetable butters*; among which we may diſtinguiſh the following:

1.

1. Butter of cacao, extracted from the cacao-nut.—There are four ſorts of cacao; the large and the ſmall caracca, the berbice, and that of the Iſlands. This butter is extracted from the nut boiling in water; it is purified by melting it by a very moderate heat.

2. The coco affords a ſimilar butter.

3. Vegetable wax is of the ſame nature, only more ſolid. It is the production of China. It is there made into yellow, white, or green candles, the colour varying with the manner in which the wax is extracted. The catkins of birch and poplar afford a ſmall quantity of a ſimilar wax.—That of Louiſiana is more plenteous. M. Berthollet eaſily whitens it with oxigenated muriatic acid.

Fixed oils are much uſed in the arts, and in medicine, and are applied to various purpoſes. In the latter they are uſed as ſoftening, relaxing, calming, and laxative medicines. Some of them are even purgative; as, for inſtance, the *Oleum Ricini*, which has been found to deſtroy the tænia, or ſolitary worm, and cauſe it to be evacuated. They enter into a great many compound medicines, ſuch as balſams, unguents, and plaſters.—Laſtly, they are ſometimes uſed as ſeaſoning, or food, on account of their agreeable taſte, and the mucilage which they contain.

CHAP.

CHAP. XV.

Of Volatile Oils.

VOLATILE or *eſſential* oils are diſtinguiſhed from fixed oils by the following peculiar properties.—Their ſmell is ſtrong and aromatic: They are ſo volatile, that they may be diſtilled by the heat of boiling water: Their taſte is very acrid: They are much more combuſtible than the other claſs of oils.

Theſe oils are found to exiſt in almoſt all odorous plants. They are contained either in the whole plant, as in the angelica of Bohemia, or only in the root of the plant, as in ſtarwort, the iris, white dittany, and kidney; or in the ſtem, as in ſandal, ſaſſafras, and pine-wood; or in the bark, as in cinnamon. Sometimes it is confined to the leaves, as in balm, peppermint, worm-wood, &c. In other plants, it is found in the calices of the flowers: Of this kind are the roſe and lavender; the petals of camomile and the orange-flower are filled with it. It is, at other times, fixed in the fruits, as in cubebs, pepper, and juniper-berries. Laſtly, A number

of

of vegetables contain it in the ſeed; ſuch as nutmeg, aniſe, fennel, and the many umbelliferous plants.

Theſe oils differ from one another, 1. In their quantity, which varies according to the ſtate or age of the plant: 2. In conſiſtency; ſome are very fluid, ſuch as thoſe of lavender, rue, &c.; ſome congeal by cold, ſuch as oil of aniſe, and fennel; others are always concrete, of which kind are the oils of roſes, parſley, kidney-wort, and ſtar-wort: 3. In colour; ſome are deſtitute of colour; others, ſuch as oil of lavender, are of a pale yellow; or a dark yellow, as oil of cinnamon; or blue, as oil of camomile; or ſea-green, as oil of St John's-wort; or green, as oil of parſley: 4. In gravity; ſome ſwim on the ſurface of water, moſt of thoſe, indeed, that are produced in temperate countries; others ſink to the bottom of that fluid, as oil of ſaſſafras, of carraway-ſeeds, and moſt oils of this kind from hot countries: this property, however, is not conſtant with reſpect to climate, for the eſſential oils of pepper, nutmegs, and mace, &c. are lighter than water: 5. In taſte and ſmell; the taſte of an eſſential oil is often very different from that of the plant from which it was extracted; pepper, for inſtance, affords, a mild oil, and oil of wormwood is not bitter.

Volatile oils are extracted, 1. By preſſure, from codra, bergamot, lemons, oranges, &c.; this is called *eſſence*: 2. By diſtillation; the plant is put into the cucurbite of a copper alembic, with water; the water is boiled, and the oil paſſes together with the fluid, and gathers above it in a receiver prepared for their reception.

Volatile oils are adulterated either by fixed oils, which is detected by their ſtaining paper; or by oil of turpentine,

pentine, which may be diſcovered by the ſtrong ſmell peculiar to turpentine, which always remains after the eſſential oil is evaporated; or by alcohol, and then water, by rendering the mixture turbid, detects the alteration produced by this ſubſtance.

Volatile oils loſe their ſmell by a moderate heat. As they are ſo very volatile, fire does not decompoſe them. When heated in cloſe veſſels, they give out a large proportion of hydrogenous gas. When heated in contact with air, they take fire ſpeedily, and exhale a very thick ſmoke, which is condenſed into a very fine, light, carbonaceous matter: They leave but very little coaly reſidue after inflammation, being ſo volatile, that the carbonaceous matter is carried off along with the part that is volatilized.

When expoſed to the air, they become thick, and, in proceſs of time, are converted into reſins. They depoſite needled cryſtals, like thoſe of ſublimated camphire. Geoffroy the younger obſerved theſe cryſtals in the volatile oils of mother-wort, marjoram, and turpentine. Their ſmell, he informs us, is much the ſame with that of camphire. *Acad.* 1721, *page* 163.

They combine with ſome difficulty with lime and alkalis; and form with theſe ſubſtances imperfect ſoaps, to which we give the name of *ſaponulæ*: Acids alter them; the concentrated ſulphuric acid changes them into bitumens; when weak, it forms with them a ſort of ſoap. The nitrous acid inflames them; the muriatic acid reduces them to a ſaponaceous ſtate; the oxigenated muriatic acid thickens them.

They act not upon neutral ſalts.

They

LIBRARY OF THE BOMBAY

They combine very eaſily with ſulphur, with which they form compounds that are called *balſams of ſulphur*, in which the ſulphur is ſo divided that it cannot be extracted, but is ſeparated by heat in the form of ſulphurated hydrogenous gas.

Mucilages and ſugar render them ſoluble in water. They are uſed in medicine as cordials, ſtimulants, antiſpaſmodics, &c. Externally applied, they are powerful antiſeptics, and ſtop the progreſs of caries in the bones.

CHAP. VIII.

Of the Camphorate Principle.

CAMPHOR is a white matter, concrete, cryſtalline, and of a ſtrong taſte and ſmell; in ſome of its properties nearly allied to volatile oils, but widely diſtinguiſhed from them by others.

Chemiſts have, from a great variety of obſervations, concluded camphor to be an immediate principle of vegetables, which, they think, exiſts in all highly odorous plants that contain volatile oil. It has, in fact, been obtained from the roots of the cinnamon tree, zedoary, thyme, roſemary, ſage, and many other labiated plants, either by diſtillation or decoction, as has been obſerved by Cartheuſer and Neumann. But the quantity of the camphor thus obtained is very ſmall, and it always retains a ſmell of the plant from which it was extracted. This ſingular ſubſtance appears to be combined with the volatile oils of theſe vegetables, as thoſe oils have been obſerved by Geoffroy to depoſite needles of camphor. I have ſeen, in the poſſeſſion of M. Joſſe, apothecary at Paris,

Paris, true camphor extracted from the root of elecampane. Lorry thought camphor a very general principle in vegetables, and placed its aromatic flavour at the head of a claſs of very powerful odours, the effects of which on the animal œconomy well merit the attention of phyſicians. M. Prouſt has publiſhed a Diſſertation, in which he deſcribes a proceſs for obtaining camphor in conſiderable quantity from the oils of ſeveral aromatic plants that grow in Mureil.

The camphor uſed in medicine is extracted from a ſort of bay-tree that grows in China, Japan, and in the iſles of Borneo, Sumatra, Ceylon, &c. The tree which produces it, often contains it in ſuch abundance, that very large and pure tears of camphor may be obtained from it ſolely by ſplitting the wood. It is commonly, however, extracted by diſtillation. The roots, or other parts of the tree, are put into an iron alembic, with water, covered over with a capital, containing ropes of rice-ſtraw, and thus expoſed to heat. The camphor is ſublimated in ſmall greyiſh grains; and theſe again unite into larger pieces. This crude camphor is impure. The Dutch purify it by ſublimating it in a ſort of balloon, and adding an ounce of lime to the pound of crude camphor.

Camphor is much more volatile than the eſſential oils; for the gentleſt heat is ſufficient to ſublimate it. It cryſtallizes in hexagonal plates, with a ſtem in the middle. When a ſtrong heat is applied, it melts before volatilizing. It does not appear to be decompoſable by this means: however, when diſtilled a number of times ſucceſſively, it affords a reddiſh phlegm, evidently of an acid nature; and this ſhews, that if the proceſs

were carried farther, its nature might at length be altered. The temperature of ſummer is ſufficient to volatilize camphor. When expoſed to the air, it is entirely diſſipated and loſt; when incloſed in cloſe veſſels, it is ſublimated in hexagonal pyramids, or in polygon cryſtals, which were, in the year 1756, obſerved and deſcribed by Romieu. It exhales a ſtrong ſmell, too ſtrong indeed for the nerves of ſome people to bear. It takes fire very eaſily, burns with a good deal of ſmoke, and leaves no coaly reſidue.

It is not ſoluble in water; it will, however, communicate its ſmell to water: it burns on its ſurface. Romieu has obſerved, that ſmall pieces of camphor, one third, or one fourth of a line in diameter, when put into a glaſs of pure water, move round, till they are at length diſſolved in about the ſpace of half an hour. He ſuſpects this motion to be an effect of electricity; and obſerves, that it ceaſes when the water is touched with any body that can act the part of a conductor, ſuch as iron-wire; and that, on the contrary, it ſtill continues, though the water be touched with an inſulating body, ſuch as glaſs, reſin, ſulphur, &c.

Earths, ſalino-terrene ſubſtances, and alkalis, are incapable of acting on camphor. We muſt obſerve, however, that the power of cauſtic alkalis on this ſubſtance, has not yet been brought to trial.

Acids, when concentrated, diſſolve camphor. The ſulphuric acid diſſolves it, with the help of heat: the ſolution is red. The nitric acid diſſolves it ſlowly: this ſolution is yellow. As it ſwims over the acid in the ſame way as oils, it has been improperly called *oil of camphor*. M. Koſegarten has diſcovered, as has been

taken notice of in the VIIth Chapter, that the nitric acid, when diſtilled eight times ſucceſſively upon camphor, changes into a cryſtallizable acid, which he thinks to be of a peculiar nature.

The muriatic acid gas diſſolves camphor; ſo likewiſe do the ſulphureous acid gas, and the fluoric acid gas. When water is poured into theſe ſolutions, they become turbid; the camphor is ſeparated in flakes, which ſwim on the ſurface of the liquor, and appear to have ſuffered no alteration. Alkalis, the ſalino-terrene ſubſtances, and metallic matters likewiſe precipitate theſe ſolutions.

Neutral ſalts act not upon camphor. We know not in what manner ſulphur and bitumens act upon this ſubſtance; but they are probably capable of combining with it.

The fixed and the volatile oils diſſolve camphor with the help of heat. Theſe ſolutions, when cooled, depoſite, by degrees, cryſtals in a vegetative form, ſimilar to thoſe that are formed in ſolutions of ammoniacal muriate; that is, conſiſting of a ſtalk, with very fine filaments extending from it horizontally. Theſe filaments, which in their diſpoſition reſemble the beard of a feather, exhibit a very beautiful and regular appearance, when viewed through a microſcope. We owe this fine fact to Romieu, (*Academy* 1756, *page* 448.) The ſolution of camphor in alcohol, which is much better known, and much more in uſe than the preceding ſolution, was obſerved by the ſame chemiſt to afford, by a particular proceſs, a ſpecies of cryſtallization ſomewhat different.

Camphor is one of the moſt potent remedies which medicine employs. It diſpels inflammatory tumours in a

very ſhort time. It is uſed as an antiſpaſmodic and antiſeptic medicine, in infectious diſtempers, the malignant fever, and all diſeaſes in general that are attended with affections of the nerves and putridity. In France, it is given only in doſes of a few grains: In England and Germany, they go ſo far as to give it in doſes of ſeveral drachms a-day. It is alſo worthy of being mentioned, that camphor alleviates burnings, and pains in the urinary paſſages, ſo ſpeedily often as might tempt the patient to think his relief the effect of enchantment. It is given either triturated with the yolks of eggs, ſugar, and gums, or in the ſtate of oil of camphor, and always in certain drinks prepared for the purpoſe. Surgeons apply camphorated ſpirit of wine, of the compoſition of which we ſhall hereafter give an account, to external gangrenes; and the liquor often puts a ſtop to their progreſs.

CHAP.

CHAP. XII.

Of the Spiritus Rector, or the Aromatic Principle of Plants.

BOERHAAVE gives the name of *ſpiritus rector* to that principle to which plants owe their ſmell: very little, however, is as yet known concerning the properties of this ſingular ſubſtance, which, from its influence on the animal œconomy, ſo ſtrongly attracts our notice. We uſe the name *aroma*, inſtead of *ſpiritus rector*, deriving it from the well-known term *aromatic*.

The aromatous principle of plants appears to be very volatile, very fugitive, and very ſubtle; it is continually diſengaged from plants, forming around them an odorous atmoſphere, of a wider or a narrower extent. Plants differ all from one another in the quantity, the ſtrength, and the nature of their aromatous principle. Some are plenteouſly provided with this principle, and loſe it only in part when dried, ſo that it would appear to be in ſome meaſure fixed in them: of this kind are in

general all odorous woods, and all the dry and ligneous odorate parts of vegetables. In others, this principle is ſo fugitive and volatile, that though they be ſtrongly odorous, they can ſcarce be rendered permanently ſo. Laſtly, there are ſome plants which poſſeſs the odorous principle in ſo low a degree, that they are ſaid to be inodorous, and their *aroma* has been diſtinguiſhed as *herbaceous*.

The ſlighteſt degree of heat is ſufficient to diſengage the aroma of plants. To obtain it, the plant muſt be diſtilled in a *balneum-mariæ*, and its vapours received into a cold capital, which may condenſe, and conduct them in a fluid ſtate into the receiver. The product is pure odoriferous water, and is known by the name of eſſential or diſtilled water. This liquor is to be conſidered as a ſolution of the odorous principle in water. That principle is more volatile than the water in which it is diſſolved. This aromatic water, when heated, loſes by degrees all its ſmell, and becomes inſipid. It ſuffers the ſame alteration when expoſed to air; it then depoſites very light flakes, of a mucilaginous appearance, and acquires a ſmell of mouldineſs.

The principle of ſmell combines with oily juices; and even appears to conſtitute one of the elementary principles of volatile oils; for, 1. Theſe oils are always impregnated with it; 2. Thoſe plants in which the principle of ſmell is conſiderably fixed, afford invariably more volatile oil than thoſe of which the ſmell is very fugitive; many of which, as, for inſtance, thoſe of the lily kind, often afford no volatile oil at all. The aroma of this latter claſs of plants, ſuch as the tuberoſe and the odoriferous lily, needs to be combined with fixed

oils,

oils, in order to prevent its eſcape. The jaſmine, too, is of the ſame character. The flowers of theſe plants are put into a tin cucurbite with cotton, moiſtened with oil of ben; the flowers and the cotton are diſpoſed in alternate layers; the cucurbite is then ſhut, and expoſed to a gentle heat: The aroma, diſengaged from the flowers, then combines with the oil, ſo as to become permanently fixed. 3. Plants that have no ſmell, never afford a ſingle particle of volatile oil. 4. Vegetables, from which aromatic water has been extracted by diſtillation on the balneum-mariæ, no longer afford any volatile oil; at leaſt, unleſs they ſtill retain ſome little ſmell; and even in that caſe they afford but a very ſmall quantity of oil. 5. Volatile oil that has loſt its ſmell, readily regains it with all its properties, when diſtilled with a freſh plant of the ſame ſpecies with thoſe from which it was at firſt extracted.

The action of ſaline matters on aromatic water has not yet been examined. M. Berthollet has diſcovered, that the oxigenated muriatic acid often deſtroys the ſmell of vegetables, and of conſequence alters their aroma. It has of late been uſed to determine the degree or intenſity of the aroma of ſeveral ſubſtances that are uſed as perfumes.

The nature of this principle is not the ſame in all plants; it varies according to the genera of the plants to which it belongs. Macquer follows Boerhaave in thinking, that it is generally a compound of an inflammable ſubſtance with a ſaline matter; but obſerves, that it ſometimes partakes more of a ſaline nature, and at other times approaches nearer in nature to oily matters. The aroma of cruciform plants, he thinks to be

ſaline;

ſaline; and aſcribes to it to the characteriſtics of being pungent and penetrating, yet not affecting the nerves: That, again, which is inſipid, or ſtrong, but not pungent, and affects the nerves, ſo as either to occaſion, or to mitigate, fits owing to the particular ſtate of the nervous ſyſtem,—effects which aromatic and narcotic plants uſually produce;—that, according to this celebrated chemiſt, has more of an oily than of a ſaline nature. Several facts concur to ſupport this opinion. The fraxinella diffuſes an odour which forms an inflammable atmoſphere around it; and whenever a burning body comes within this atmoſphere, it takes fire; and the vapour then burns from the lower to the upper part of the ſtem that ſupports the flowers.

The aroma of the fraxinella ſeems therefore to be of an oily nature. Venel, a chemiſt at Montpelier, who ſtudied under Rouelle, extracted an acid ſpiritus rector from ſavoy (marum) by a gentle heat; and Roux, profeſſor of chemiſtry in the ſchools of medicine, having examined the product, found that it did not redden vegetable colours, but ſaturated alkalis. With reſpect to the aroma of cruciform plants, chemiſts are not yet agreed concerning its nature. Some think it acid; others call it alkaline. It appears from the experiments of Meſſrs Deyeux and Baumé, that ſulphur is found in combination with the odorate principle of antiſcorbutic plants; and that it is this combuſtible body, reduced to the ſtate of elaſtic fluidity, by combination with hydrogene, which conſtitutes the aroma of cruciform plants.

There are yet two important obſervations to be made concerning the aroma of plants. In the firſt place, it is perhaps, as Macquer ſuſpected, a gas of a peculiar nature:

ture: its inviſibility, its volatility, the manner in which it diffuſes itſelf through the atmoſphere, its power of expanſion, together with ſome experiments by Dr Ingenhouſz on the noxious gas exhaled from flowers, render this opinion highly probable.—What we want to determine this point, is a ſeries of experiments, which would indeed require to be performed with the utmoſt care and accuracy, but would certainly accompliſh ſome noble and uſeful diſcoveries. Boyle has already opened a wide field of inquiry concerning ſmells, their alterability and reciprocal combination: and that train of reſearch has been very ſucceſsfully proſecuted by Lorry. This philoſopher has obſerved the alterations produced on them by mixture with one another, by fermentation, and by the action of fire, air, and different menſtrua.—We cannot, without making an improper digreſſion, enter here into a particular detail of his experiments; but we may mention his general diviſion of ſmells. Lorry divides theſe bodies into five claſſes, camphorate, æthereal, poiſonous, or narcotic, acid, and alkaline: All ſmells may, in his opinion, be referred to ſome one of theſe claſſes. In explaining the grounds on which he eſtabliſhes this diviſion, founded on the manner in which ſmells affect the ſenſe of ſmelling, and the nerves in general, Lorry informs us, that he propoſes not to examine their chemical nature: But it is probable, as he himſelf thinks, that thoſe of each claſs are nearly of the ſame nature in reſpect to chemical properties, as well as to the manner in which they affect the animal œconomy.

Our ſecond obſervation, and with it we mean to conclude the chemical hiſtory of the principle of ſmell, is, that though the plants which have been called inodorous,

rous, be thought to contain none of this principle; yet is it at preſent a well known fact, that, by the gentleſt heat of a balneum-mariæ, there may be extracted from them a water, of which the ſmell, though very faint, will however be ſufficient to indicate from what plant it was extracted.—I can aſſert this upon my own experience. I have often found thoſe plants that are commonly reckoned the moſt inodorous, ſuch as ſuccory, plantain, borage, &c. to afford, by the balneum-mariæ, a water that diffuſes a ſmell, by which the nature of the plant from which it was extracted may be ſufficiently known. It is true, that theſe inſipid aromatic waters are very ſoon decompoſed, and loſe, in a ſhort time, that faint ſmell by which they are diſtinguiſhed: They are altered, and ferment, and paſs either into an acid or an alkaline ſtate.

The perfumer's art is founded on the method of extracting the odorous parts of vegetables, of preſerving, and of fixing them in different ſubſtances. Moſt of the proceſſes of that art are entirely chemical.

Medicine, too, makes much uſe of diſtilled or aromatic waters. They poſſeſs different virtues, according to the peculiar nature of each. Thoſe employed for the purpoſes of medicine are uſually diſtilled by naked fire, with water, in the ſame way as volatile oils. This manipulation anſwers very well for the aroma of ſuch waters as are truly aromatic, but not ſo well with thoſe plants that are commonly called inodorous. Theſe ought to be diſtilled in a balneum-mariæ; and as this precaution is ſeldom taken, they have uſually an empyreumatic ſmell, acquired from the fire, even when not impregnated with the odorous principle of the plant.—If theſe waters owe all their virtue to the aroma which they contain, weak as

that

that is, it is certain that the mode of preparing them deſtroys all the properties which that principle can poſſibly confer upon them.

To theſe obſervations we ſhall only add, that the diſtilled waters of plants prepared by the apothecary, are not that pure aroma which Boerhaave called *ſpiritus rector*, but that principle, diluted in a large proportion of water, diſtilled with the plants.

CHAP.

CHAP. XIII.

Of Reſinous Inflammable Juices in general, and of Balſams in particular.

THE name *Reſins* is given to certain dry inflammable matters, which cannot be mixed with water, but are ſoluble in oils and alcohol, and run fluid from the trees in which they are produced. Theſe matters are nothing but oils concreted by the deſiccative action of the air. Various opinions are entertained concerning the difference between balſams and reſins. Some give the name of balſams to inflammable fluid ſubſtances; but there are alſo dry balſams: Others confine the name to the moſt odorous inflammable ſubſtances. Bucquet has thrown much new light on this matter, by confining the name of *balſams* to ſuch of theſe combuſtible matters as are ſweet-ſmelling, and can communicate their ſmell to water; and eſpecially, which contain odorate and concrete acid

ſalts,

ſalts, that may be obtained from them by ſublimation, or decoction in water.

The principal ſpecies of balſams are the three following:

1. Benzoin. Of this there are two ſorts: the amygdaline benzoin, in white tears reſembling almonds, united by a brown juice; and common benzoin, of a brown colour, not in tears: it exhales a very pleaſing ſmell, when melted or pricked with a hot needle. The tree that affords it is but little known. Linnæus, the ſon, calls it terminalia benzoin. Murray obſerves, that the wood and the bark of this tree diffuſe an odour of benzoin whilſt burning. The ſame author thinks it doubtful, however, whether it affords this balſam or not. This balſam comes to us from the kingdom of Siam, and the iſland of Sumatra. On account of its ſolidity, it affords but little eſſential oil. Boiling water extracts from it an acid ſalt in needles, which is ſtrong ſmelling, and cryſtallizes by cooling. The ſalt is alſo obtained by ſublimation. When obtained by this laſt proceſs, it is called *flowers of benzoin.* This operation is performed in two varniſhed earthen pots, placed one above the other, and made cloſe with paper at the place of their junction. The fire muſt be moderate, otherwiſe the ſalt becomes brown. The paſteboard cone which was formerly uſed for this purpoſe ſuffered a great deal of the concrete acid to eſcape. We have given an account of the properties of this acid in a preceding chapter. Benzoin affords, in a retort, a very acid phlegm, a concrete brown ſalt of the ſame nature,

and brown thick oil: the reſidual coal contains fixed alkali.

Benzoin is ſoluble in alcohol; and the tincture of this balſamic ſubſtance, precipitated by water, forms *lac virginale*. Salt of benzoin is uſed as a good inciſive in pituitous diſorders of the lungs and reins. The oil is diſcuſſive, and is externally applied to limbs affected with palſy, &c.

2. Balſam of Tolu, Peru, and Carthagena. This balſam is brought to Europe, either in cocoa-nut-ſhells, or in yellowiſh tears, or in a fluid ſtate: it flows from the toluifera, which Linnæus ranks in the decandria monogynia claſs. It may be extracted from the ſhells by ſteeping them in boiling water, which renders it fluid. It comes from a country in South America, ſituated between Carthagena and Nombre de Dios, called by the inhabitants of the iſlands Tolu, and by the Spaniards Honduras. It affords, when analyſed, the ſame products as benzoin, and eſpecially a concrete acid ſalt. It is made into ſyrup, and adminiſtered in diſeaſes of the lungs.

The acid of the balſam of Tolu has not been yet examined: it is thought not to differ eſſentially from the benzoic acid.

3. Storax calamita is in tears, either red and clean, or brown and greaſy. It ſmells very ſtrong; it runs from the oriental liquid ambar, a plant that is but little known. Duhamel obſerved a juice running from the *alibouſier*, that had nearly the ſame ſmell. Neumann analyſed the ſtorax calamita, and obtained from it an eſſential oil, a concrete acid ſalt, and a thick oil. It ſerves for nearly the ſame purpoſes as benzoin;

benzoin: it is chiefly uſed for perfume. We formerly had it ſent to us in reeds; but we now get it in loaves, or irregular maſſes, of a reddiſh brown colour, mixed with a few tears of a lighter colour, and a more pleaſant ſmell.

CHAP. XIV.

Of Reſins.

RESINS differ from balſams, as having a leſs pleaſing ſmell; and, ſtill more eminently, as containing no concrete acid ſalt. The following are the principal ſpecies of reſins.

1. Balſam of Mecca, Judæa, Egypt, Grand Cairo: It is liquid, white, bitter, and of an high lemon-colour. It runs from a tree that is called *amyris opobalſamum*, ranked by Linnæus in the octandria monogynia, and diſcovered in Arabia the Happy by M. Forſkahl. This liquid reſin affords a great deal of eſſential oil by diſtillation. With ſugar, and yolks of eggs, &c. it is uſed as a vulnerary.

2. Brown or yellow balſam of Copahu, which runs from the tree called *copaiba*, and by Linnæus *copaifera*, and ranked by that botaniſt in the decandria monogynia. The common kind, both of this and of the balſam of Tolu, is, according to Cartheuſer, a mixture of genuine

genuine balſam of Copahu with turpentine. It is uſed, as well as the preceding reſin, as a remedy for ulcers of the lungs and bladder.

3. Chio turpentine runs from the turpentine-tree that bears the piſtachio-nuts. It is of a white or yellow colour, inclining to blue. It affords, on a balneum-mariæ, a very fluid volatile oil: that which it affords by naked fire is not ſo fluid. The turpentine is, after this operation, of a ſtill yellower colour. When diſtilled with water, it is white and ſilky, and is called *boiled turpentine*. This turpentine is not common, and is not applied to any uſe.

4. Venetian turpentine, or Mileſian reſin, is that moſt commonly uſed in medicine. It is uſed either in its natural ſtate, or combined with fixed alkali. This compoſition has been called *Starkey ſoap*. We conſider it as a *ſaponula*. To prepare it, the Paris Diſpenſary directs to pour four ounces of volatile oil of turpentine on half a pound of nitre fixed by tartar, and ſtill hot; to ſtir the mixture with an ivory ſpatula, and cover the veſſel with a piece of paper; adding oil, by degrees, till the whole form one white maſs. This proceſs takes up ſeveral months; and chemiſts have therefore ſought to find out ſome more expeditious method of making up the medicine. Rouelle prepared, in the ſpace of three hours, a pretty conſiderable quantity of this ſoap, by triturating alkali with the oil dropped upon it, and adding a little water towards the end of the operation. M. Baumé directs to levigate upon porphyry one part of alkali of tartar, previouſly expoſed to heat till it ſhall have been brought near the point of fuſion; and to add to it, by

degrees, two or three times its weight of volatile oil. When the mixture is brought to the conſiſtency of a ſoft opiate, put it into a glaſs-cucurbite, covered with paper, and ſet it aſide in a damp place. In fifteen days time, the deliqueſcent alkali forms a diſtinct portion of liquor at the bottom of the veſſel; the ſoap occupies the middle; and a portion of the oil, having aſſumed a red colour, ſwims on the ſurface. M. Baumé thinks that the alkali unites only with that portion of the oil which is in a reſinous ſtate. M. le Gendre purſues this idea farther, and propoſes to ſaturate a cold ſolution of the fixed alkali with concentrated oil of turpentine, or even with turpentine itſelf. This ſoap is in ſome degree ſolid, and becomes gradually more ſo: cryſtals are formed in it, which have been conſidered as a combination of the acid of the oil with vegetable fixed alkali. But, according to the academicians of Dijon, they are nothing but potaſh ſaturated with carbonic acid, and cryſtallized in that ſtate. As it is no eaſy matter to make up this ſoap, and it is, beſides, very liable to alteration, Macquer thinks, that when a ſubſtance is wanted, poſſeſſing the properties of volatile oils, and thoſe of ſoaps, in union, it were better on any occaſion to incorporate a few drops of volatile oil with medicinal white ſoap, to ſerve the preſent purpoſe. Ammoniac, triturated with turpentine, forms a ſolid ſaponaceous compound, which diſſolves very readily with water, and renders it milky and frothy.

5. The reſin of the fir-tree is called turpentine of Straſburg. It is obtained by piercing the veſiculæ of the

the bark of the fir-tree, of which there are extenſive foreſts on the hills of Switzerland.

6. Pitch is the juice of a ſort of a fir-tree, called *abies picea.* It is obtained, by inciſion, from the bark of the tree. It is melted by a moderate fire, preſſed in bags of cloth, and received into barrels: This is Burgundy pitch, or white pitch; by mixture with lamp-black, it is converted into black pitch. When it is kept long in fuſion with vinegar, it becomes dry and brown, and ſo forms what is called *Colophony.* The more impure parts are burnt in a furnace, with a chimney paſſing into a ſmall cabinet, terminating in a cone of cloth: the ſmoke is condenſed in this cone, into a fine ſoot, that is called *lamp-black.*

7. The galipot is the reſin of the pine which bears the ſoft apples. This tree is notched towards the bottom, and the reſin runs out into troughs. When the reſin ceaſes to run out by the lower holes, they are continued upon the tree. When it runs fluid, it is called *galipot;* that which hardens upon the tree into yellowiſh maſſes, is called *Barras.* Theſe juices are liquified in boilers; and after being concentrated by heat, are filtrated through ſtraw-mats, and run into moulds in ſand, or formed into loaves that are called *arcançon,* or *bray-ſec.* When water is poured in, the matter becomes white, and forms *reſin,* or *pitch-reſin.* The inhabitants of Provence diſtil galipot: they extract from it an oil which they call *huile de raze.* *Tar,* which is the empyreumatic oil of this ſubſtance, is prepared from the trunk and roots of the pipe. A quantity of the wood is heaped together, covered with

turf, and ſet on fire. The turf hinders the oil that is diſengaged by the heat from being volatilized; and it paſſes into a ſhallow tub through a channel, out of which it is removed, without farther preparation, to be ſold as *tar*.

8. Tacamahaca, gum elemi, gum animæ, are very little uſed. The tree that affords the firſt is unknown. The *elemi* is produced by a ſpecies of *amyris*. The oriental gum animæ, or copal, the origin of which is unknown, and the occidental gum animæ, or courbaril, which flows from the *hymenæa*, a tree that grows in South America, are uſed for varniſhes.

9. Maſtic is in white, farinaceous tears, of a faint ſmell: It flows from the turpentine tree, and the maſtic tree; it is uſed as an aſtringent, and an aromatic; it enters into the compoſition of drying varniſhes.

10. Sandarac is in white tears, more tranſparent than thoſe of maſtic. It is obtained from the juniper-tree, in which it occupies a place between the bark and the wood. It is likewiſe called *varniſh*, as it enters into thoſe preparations. It is uſed, in powder, to prevent ink from ſinking on paper, from which the external coating of ſize has been ſcraped off.

11. The reſin of guayacum, which is greeniſh, is uſed as a remedy for the gout. It is obtained, by inciſion, from the guayacum tree.

12. Labdanum the reſin of a ſpecies of ciſtus in Candia, is of a blackiſh colour. The peaſants gather it by ſtriking the trees with ſtaves, having a number of leather-thongs fixed to the one end. They make it up into cylindrical pieces, which they call *ladanum in tortis*.

It is adulterated by a copious addition of blackiſh ſand: It is uſed as an aſtringent.

13. Dragon's blood is a red juice, extracted from the *dracæna draco*, and ſome other trees of a ſimilar nature. It comes to us in ſmall flat cakes, or round balls, or in little ſpherical pieces, wrapped up in leaves, and knotted like a chaplet. It is uſed in medicine as an aſtringent.

CHAP. XV.

Of Gum Reſins.

GUM RESINS are mixed juices, conſiſting of reſin and extractive matter, which has been taken for a gummy ſubſtance. They run by inciſion, but never naturally, from trees or plants, in the form of white, yellow, or red emulſive fluids, which are ſooner or later conſolidated. Water, alcohol, wine, vinegar—none of all theſe liquors diſſolves more than a part of gum reſins. They differ in the proportions of the reſin and the extract, and afford, by analyſis, many various reſults. The following are the moſt important ſpecies:

1. Olibanum conſiſts of yellow tranſparent tears, of a very ſtrong and diſagreeable ſmell. It is not known from what tree it flows. It affords, by diſtillation, a ſmall portion of volatile oil, and an acid ſpirit, leaving a pretty large reſidual coal, produced from the extractive matter which it contains. It is uſed in fumigations as a reſolvent medicine.

2. Galbanum is a fat juice, of a brown-yellow colour, and

and a nauſeous ſmell. It runs, in Arabia, Syria, and at the Cape of Good Hope, from inciſions in a ferulaceous plant, called *Bubon Galbanum* by Linnæus. When diſtilled by naked fire, it affords a blue eſſential oil, which afterwards becomes red, an acid ſpirit, and a ponderous empyreumatic oil. It is an excellent diſcuſſive, and a powerful antiſpaſmodic.

3. Scammony is of a blackiſh grey colour, a ſtrong nauſeous ſmell, and a bitter and very acrid taſte. The ſcammony of Aleppo is by far the pureſt. That of Smyrna is ponderous, black, and mixed with extraneous bodies. It is extracted from the *convolvolus ſcammonia* of Linnæus. The root of the plant, cut and ſqueezed, affords a white juice, which, when dried, becomes black. The various ſpecimens of ſcammony contain various proportions of extract and reſin; on which account its effects as a medicine are far from uniform. It is given as a purgative, in dozes of from four to twelve grains. Mixed with a ſweet extract, ſuch as that of liquorice, it forms the common *diagredium*. It is likewiſe uſed for this purpoſe with the juice of quinces. It is uſually given in a powder with ſugar and ſweet almonds.

4. Gum guttæ is yellow, reddiſh, deſtitute of ſmell, and of a ſtrong, acrid, and corroſive taſte. It comes from Siam, China, and the iſland of Ceylon. It is extracted from a large tree, very little known to us, and diſtinguiſhed in the countries where it grows by the name of *Coddam Pulli*. It contains a good deal of reſin, which renders it ſtrongly purgative, when adminiſtered in dozes of four or ſix grains. It ſhould be very cautiouſly adminiſtered internally.

5. Euphorbium is in yellow tears, which are of a carious or worm-eaten appearance, and have no ſmell. It runs from inciſions in the plant *euphorbium*, which grows in Ethiopia, Lybia, and Mauritania. It contains a very acrid reſin. It is ſo ſtrongly purgative, as to be ranked among poiſons. The only medical uſe for which it ſerves, is in external applications to caries.

6. Aſſa-fœtida is ſometimes in yellowiſh tears, but oſteneſt in loaves, conſiſting of different pieces agglutinated together. It has a very fœtid ſmell of garlic, and taſtes bitter, and nauſeouſly diſagreeable. It is extracted from the root of a ſort of *ferula* that grows in the province of Chorazan in Perſia, and has been called by Linnæus *Aſſa-fœtida*. The root of this plant is fleſhy and ſucculent. It affords, by expreſſion, a white juice, of an abominable ſmell, uſed by the Indians as a ſeaſoning, and called by them *food for the Gods*. It is uſed internally as a powerful antiſpaſmodic, and externally as a diſcuſſive.

7. Aloes is a juice of a dark red, and ſometimes even a brown colour, with conſiderable bitterneſs of taſte. There are three kinds of it: ſocotorine aloes, hepatic aloes, and caballine aloes. The firſt is the pureſt; and it is only in purity the three ſorts differ. A. de Juſſieu ſaw theſe ſeveral kinds of aloes prepared at Morviedro, in Spain, from the leaves of the common aloes. Deep inciſions were made in the leaf; the juice ran out by theſe: It was then decanted from above the fæcula, and thickened by expoſure to the ſun. The aloes prepared in this manner is put up in leather-bags, and ſold under the name of ſocotorine aloes. The juice ſqueezed from the leaves, purified by reſt, and then dried, forms hepatic

hepatic aloes. Laſtly, The leaves are again preſſed; and the juice now obtained from them, mixed with the lees remaining from the two former operations, forms caballine aloes. The firſt of theſe different ſorts of aloes contains much leſs reſinous matter than either of the two latter, and is therefore much leſs purgative. It is uſed in medicine as a draſtic purge, and is known to poſſeſs the property of bringing on the menſtrual flux with women, and the hæmorrhoidal flux with men. It is recommended as an excellent hydragogue.

8. Myrrh is in the form of reddiſh tears, of a brilliant appearance, of a pretty ſtrong but agreeable ſmell, of a bitter taſte, and exhibiting in their fracture, when broken, white lines of the form of a nail. Some of theſe tears are entirely gummy and inſipid. Myrrh comes from Egypt, but chiefly from the ancient country of the Troglodytes, in Arabia. The plant that affords it is unknown to us. It contains much more extract than reſin. It is uſed in medicine as a very good ſtomachic, an antiſpaſmodic, and a cordial. Cartheuſer adviſes literary people, who have delicate ſtomachs, to chew and ſwallow it with their ſpittle. It is uſed in ſurgery for cleanſing putrid ulcers, and ſtopping the progreſs of caries, either in powder, or diluted in ſpirit of wine.

9. Gum ammoniac ſometimes appears in tears that are white internally, but externally yellow, and often in maſſes much like thoſe of benzoin. They are eaſily diſtinguiſhed, however, by their white colour and fœtid ſmell. This gum reſin, which we get from Africa, is thought, on account of the ſeed mixed with it, to be extracted from an umbiliferous plant. This ſubſtance being ſoluble in water and ſpirit of wine, as well as inflammable, is

is nearly of the ſame character with thoſe which Roucłle has named reſinous extractive matters.

In medicine, gum ammoniac is uſed as a very good diſcuſſive in caſes of obſtinate obſtruction. It is given in doſes of a few grains, either in pills or emulſions: it enters alſo into the compoſition of many diſcuſſive and reſolvent plaſters.

10. Elaſtic reſin, or caout-chouc, is a ſubſtance concerning the nature of which it is hard to ſay any thing. Its containing combuſtible matter, which is uſed in America for lights, is a characteriſtic in which it agrees with reſinous ſubſtances: but its elaſticity, ſoftneſs, and inſolubility in the menſtrua, which uſually diſſolve reſins, diſtinguiſh it as a ſubſtance of a different nature.

The tree which affords it, grows in various parts in America. Large inciſions are made through its bark, which muſt always penetrate to the wood: a white juice, more or leſs fluid, flows from it, and is received into veſſels, in order that it may be applied to the different purpoſes for which it is ſuitable: it is laid in layers on clay moulds; and dried by expoſure to the ſun, or to fire. Various deſigns are then ſketched upon them with the point of an iron inſtrument: they are then expoſed to ſmoke; and when ſufficiently dried, the moulds are broken. In this way are formed the bottles, and other utenſils of elaſtic gum, that come into Europe.

The veſſels made of this matter are capable of holding water, and ſuch other fluids as have no power of acting upon it. If it be cut into pieces, and the edges applied to each other ſoon after they are cut, the pieces unite again. I examined juice of caout-chouc, which was ſent me from Madagaſcar. It was white as milk, and its ſmell inſuf-

ferably fœtid. It contained a concrete, white, ſpongy matter, in the middle of the bottle, of a ſimilar form, and likewiſe elaſtic. When the liquor was heated, a white pellicle of genuine elaſtic reſin was very ſoon formed on its ſurface. Alcohol, mixed with the juice, ſeparated from it flakes of that reſin.

When the caout-chouc, in a dry ſtate, ſuch as it is ſent into Europe, is expoſed to fire, it becomes ſoft, ſwells, exhales a fœtid odour, and ſhrinks as it burns.

Elaſtic reſin is not ſoluble in water. We know not in what manner ſaline matters act upon this ſubſtance. Macquer, after trying to diſſolve it in various menſtrua, was convinced of what had been before aſſerted by Meſſrs de la Condamine and Freſneau, (*Academy, year* 1751), that alcohol was incapable of acting upon it, but that oils diſſolved it with the help of heat. However, as he wiſhed to reduce it to a liquid ſtate, ſo that it might be made uſe of in that form, and might recover its properties by the evaporation of the ſolvent liquor, he was obliged to employ another menſtruum than oils; becauſe oils, however volatile, always altered the elaſtic reſin, and became fixed in it, ſo as to weaken its ſtrength, and deſtroy its elaſticity. He at length diſſolved this ſubſtance in highly rectified æther; and this being ſo very ſubject to evaporation, perfectly ſuited his purpoſe: (*Academy, year* 1768). And though that liquor be indeed very dear, yet he thought it might be of ſome conſequence to make known to the public a method of making ſome very uſeful inſtruments, ſuch as catheters, by putting, on a waxen mould, ſucceſſive layers of this ſolution, till they be of the required thickneſs. When the catheter is dry, let it be immerſed in boiling water, which

which, by melting the wax, ſeparates it from the mould. The ſoftneſs and elaſticity of a catheter of this ſubſtance, render it the moſt proper for perſons who find it neceſſary to wear ſuch an inſtrument conſtantly.

Theſe are all the particulars of the hiſtory of elaſtic gum that were known to the world before the month of April 1781; at which time M. Berniard, diſtinguiſhed by the accuracy of his experiments, inſerted in the *Journal de Phiſique* an excellent Memoir on this ſingular ſubſtance. That chemiſt concludes from his experiments, that elaſtic reſin is a peculiar fat oil, coloured by a matter ſoluble in alcohol, and contaminated with the ſoot of the ſmoke to which each layer of the reſin muſt be expoſed, in order to dry it. Water produces no alteration upon it: alcohol, aſſiſted by a boiling heat, diſcolours it. Cauſtic fixed alkali is incapable of acting upon it. The concentrated ſulphuric acid reduces it to a carbonaceous ſtate, and is itſelf at the ſame time tinged with a black colour, and takes the ſmell and the volatility of the ſulphureous acid. The common or weak nitric acid acts on this reſin in the ſame way as on cork, and gives it a yellow colour; the nitric acid, ſtrongly concentrated, decompoſes it very rapidly; the muriatic acid produces no ſort of alteration upon it; rectified ſulphuric æther did not diſſolve it: This fact muſt appear ſingular, as the author obſerves, to all thoſe who know the accuracy and veracity of Macquer. Nitric æther did diſſolve it. This ſolution was yellow, and afforded, by evaporation, a tranſparent ſubſtance, friable, and ſoluble in alcohol;—in a word, a genuine reſin, formed, according to this author, by the action of the nitric acid on the elaſtic caout-chouc. The volatile oils

of

of lavender, aſpic, and turpentine, diſſolved it with the help of a gentle heat; but they formed clammy fluids, which ſtuck to the hands, and could not therefore be applied to any uſeful purpoſe. A ſolution of elaſtic reſin by oil of aſpic, when mixed with alcohol, depoſited white flakes, which were inſoluble in hot water, but floated on the ſurface of that fluid, and became, by cooling, white and ſolid like wax; in a word, they formed a genuine, fixed, concreſcible oil. Oil of camphor diſſolved elaſtic reſin by ſimple maceration. When the ſolution was evaporated, the camphor was volatilized; and there remained in the capſule an amber-coloured matter, of a firm conſiſtency, but ſcarce gluey, and eaſily ſoluble in alcohol. Fixed oils, when boiled upon elaſtic reſin, diſſolve it: wax likewiſe diſſolves it. This ſubſtance does not melt by a boiling heat; but when expoſed to the action of fire in a ſilver ſpoon, it is reduced into a thick black oil: It then exhales white vapours; after which it remains fat and clammy, though expoſed to the air for ſeveral months; nor does it ever again recover its dryneſs and elaſticity, which are ſo neceſſary to fit it for the purpoſes to which it is applied. Laſtly, M. Berniard concluded his experiments on this ſubſtance, by analyſing it by naked fire. From an ounce of elaſtic gum he obtained a very little phlegm; an oil which, though at firſt clear and light, became afterwards thick and coloured; and ammoniac, the quantity of which he does not ſpecify: There remained a coal, ſimilar to thoſe of other reſinous ſubſtances, which weighed twelve grains. This chemiſt aſcribes the origin of the ammoniac to the ſoot which colours gum elaſtic.

On

On this analyſis we may obſerve, that it does not determine, in a very accurate manner, the nature of elaſtic reſin: for acids act not on this ſubſtance in the ſame way as on fat oils; they act on theſe bodies with much more rapidity than on elaſtic gum; neither do cauſtic alkalis reduce it to a ſaponaceous ſtate: nor does it melt, unleſs a much ſtronger heat be applied to it than is ſufficient to reduce the moſt ſolid fixed oils to a ſtate of fluidity: and, beſides, no fixed oil ever becomes dry and elaſtic, like elaſtic reſin, &c. &c. In his fifth experiment, too, the author aſſerts this gum to conſiſt of two diſtinct ſubſtances, the nature of which he does not explain; and concludes with repreſenting it as a product of human induſtry. From theſe reflections, and many others which might be added, concerning theſe experiments of M. Berniard's, which are in other reſpects very well performed, we are induced to think, that much ſtill remains to be done, as he himſelf acknowledges, before we can be fully acquainted with the properties of this ſubſtance, or can decide with certainty concerning its nature.

CHAP.

CHAP. XVI.

Of the Pure Fæcula of Vegetables.

THE juices of vegetables, when elaborated in their veſſels, become thick, and are by degrees depoſited on the ſurfaces of their fibres, where they contribute to their increaſe and nouriſhment, or are accumulated in a more or leſs ſolid form, in the different organs of which the vegetable conſiſts. After ſpeaking of the fluid parts of theſe organic ſubſtances, we come next to examine the ſubſtance of which the contexture of their ſolids is formed.—We are as yet far from being ſufficiently acquainted with the nature of all thoſe ſolid matters which compoſe the organs of plants. However, thoſe particulars which are known to us, on this head, ſhew that thoſe organs, when treated by proceſſes which we are going to deſcribe, are reducible to a dry, pulverulent, inſipid ſubſtance, either white, grey, or variegated with different colours, inſoluble in cold water, and ſeemingly earthy, which is called *fæculum*.

To obtain this ſubſtance, the root, ſtem, leaves, or ſeed of a plant, is pounded down to a pulp with a peſtle. When theſe parts are ſucculent, there is no occaſion for adding water to aſſiſt the proceſs; but this fluid is uſually employed to facilitate the ſeparation of the fibres, and to take up the attenuated pulverulent parts. When reduced by this proceſs to pulp, the vegetable ſubſtance is then ſqueezed; the juice or water obtained from it by preſſure is either turbid, white, or coloured; and it gradually depoſites, by reſt, a flaky matter, partly fibrous, and ſometimes pulverulent, which is the true fæculum of the plant. Some parts of vegetables appear to conſiſt entirely of this matter; ſuch as the ſeeds of gramineous and leguminous plants, tuberculous roots, &c. Theſe parts uſually afford the fineſt fæculum, and the greateſt quantity of that matter. As to the tender ſtems and leaves, their texture, being more fibrous, never affords, when treated by this proceſs, any thing but a coarſe, coloured, filamentous ſubſtance, which is known by the name of *coarſe fæculum*. If, after being thoroughly dried, theſe be reduced to powder, and the powder lixiviated, the water takes up a much finer fæculum, preciſely of the ſame nature with that of tuberculous roots and gramineous ſeeds. In the eye of the chemiſt, therefore, there is no other difference between theſe two kinds of fæcula, but that the firſt is produced from a part which is leſs fibrous, not ſo perfectly organized, and apparently formed of ſmall cells, in which Nature has depoſited a dry or farinaceous mucilage; whereas the ſecond, being wrought into a tiſſue of fibres, needs to have its organization deſtroyed, and to be attenuated by art.

Strictly

Strictly ſpeaking, all the ſolid parts of vegetables are capable of affording a ſort of fæculum. But that which is prepared for the arts, for pharmacy, and for aliments, muſt here be more immediately the object of our attention. The fæcula of briony, potatoe, caſſava, ſago, ſalop, ſtarch, are thoſe which deſerve to be particularly taken notice of, as applied to theſe purpoſes.

1. To prepare the fæcula of briony, take the freſh roots of the plant, ſtrip off the bark, raſp the root to pieces, and then ſubmit them to the preſs. The juice ſqueezed out by the force of the preſs is white, and depoſites a very fine fæculum. At the end of four and twenty hours, decant off the juice; dry the fæcula. As the juice muſt have left in it a certain quantity of extract, it is very acrid, and purges violently. If waſhed before being dried, it becomes finer and whiter, but loſes at the ſame time its purgative powers. But this way of preparing the fæcula of briony affords only a very ſmall quantity. Much more may be obtained by diluting in water the maſs which remains in the preſs, paſſing that water through a hair-ſieve, and ſuffering it to ſtand undiſturbed, till it depoſite the fæcula which it contains. When this is depoſited, let the water be decanted off, and the ſediment dried. This fæculum, obtained by waſhing the lees, is not of a purgative nature, like the former, as the water has carried off the extractive matter in which that virtue reſided. M. Baumé has obſerved, that the fæculum of briony, when well waſhed, bears an exact reſemblance to ſtarch, and that hair-powder might be made of it; by which means, the wheat made uſe of for that article would be ſpared for other purpoſes. The

fæcula of the roots of calves-foot and corn-flag are prepared in the ſame way for medical uſe.

3. Potatoes, being ſo plenteous, and affording in a crop ſuch large increaſe, form one of the moſt uſeful articles of food. We can very eaſily extract from them a great deal of very fine white fæculum, that becomes, by roaſting, boiling in water, &c. a nouriſhing article of food. This fæculum may be obtained by grating down the potatoes on a ſieve, and pouring plenty of water upon them. The fluid carries off the fineſt and moſt attenuated portion of the fæcula, and, after ſtanding for ſome time undiſturbed, depoſites it. Decant off the water; dry the fæculum by a gentle heat: it is now in the ſtate of a very fine light white powder. For the preparation of large quantities of this powder, mills, or a ſort of graters turning on cylinders, have been contrived, which appear to be very happily adapted to the purpoſe.

3. The Americans extract, from the root of a very acrid plant called *manioc*, a very pleaſant nouriſhing fæculum, to which they give the name of Caſſava. In preparing it, they ſtrip the root of its bark, grate it down, and put it into a ruſh-bag, of a conical figure, and a very ſlight looſe texture, and hang the bag upon a ſtick, reſting horizontally on two wooden forks. To the lower end of this bag they fix a very heavy veſſel, which, by its weight, ſqueezes out the juice, and, at the ſame time, receives it as it runs. The juice is a very acrid and noxious poiſon. When the fæcula are ſufficiently preſſed, and all the juice drawn off, it is then dried by expoſure to ſmoke, and paſſed through a ſieve; and now it is in a proper ſtate for being baked into caſſava.

It

It is now ſpread on a plate of hot iron, and turned till it be ſo completely roaſted, as to take on both ſides a reddiſh yellow colour. In this ſtate it is called Caſſava bread. When expoſed to heat in a baſon, and ſtirred from time to time, it takes, as it dries, a granulated form; in which ſtate it is called *couac*. From the juice that was ſqueezed from the fæcula, there is by degrees a very fine ſweet-taſted fæculum precipitated, which is called *mouſſache*, and uſed in paſtry.

4. Sago is a dry fæculum, reduced to grains, and a little reddened by the action of fire, which we get from Java, and from the Molucca and Philippine iſlands.—It is extracted from a ſort of palm-tree, called in the Moluccas *landan*. The trunk of that tree incloſes a ſweet marrow, which the inhabitants extract by ſplitting the tree longitudinally. They then ſcrape down this marrow, put it into a ſort of cone or funnel made of the bark of a tree, place the cone upon an hair-ſieve, and pour upon it a good deal of water.—The fluid conveys with it, through the holes of the ſieve, the fineſt and whiteſt part of the marrow, leaving the fibrous part ſtill upon the ſieve.—The water impregnated with the attenuated part of the marrow is received into pots, in which the fæculum is ſoon depoſited, and it becomes tranſparent.—The water is now decanted off, and the ſediment paſſed through ſmall plates perforated with holes, which give it the granulated form by which ſago is uſually diſtinguiſhed.—The reddiſh colour of the ſurfaces of the grains is owing to the action of the fire by which they are dried.—Theſe grains become ſoft and tranſparent in boiling water. With milk or broth, they make a

ſort of ſoup, which is light, and pleaſant to the taſte, and is greatly recommended in phthiſical caſes.

5. Salep, ſalop, ſalab, &c. is a ſubſtance which the inhabitants of the Eaſt prepare from a ſpecies of *orchis*. They ſelect the fineſt bulbs of that plant, firſt peel them, and then ſteep them in cold, and boil them in hot water; next, after the water is well drained from them, they are ſtrung in bunches, and dried in the air. M. Jean Moult gives another proceſs for the preparation of ſalep, by which it may be prepared from any ſpecies of orchis.—The roots muſt be rubbed, either dry or in water, with a bruſh, to remove the exterior pellicle, and then dried in an oven. They then become very hard and tranſparent. But they may be very eaſily reduced to a powder; and this powder, diluted in hot water, forms a nouriſhing jelly; the virtues of which Geoffroy mentions with very laviſh praiſe, as highly efficacious againſt all diſeaſes occaſioned by an acridity of the lymph, more eſpecially againſt conſumptions and the bilious dyſentery.

CHAP.

CHAP. XVII.

Of the Farina of Wheat, and of Starch.

STARCH, properly ſo called, is a fæculum preciſely of the ſame nature with thoſe of which we have already given an account: But as the farina of wheat, of which ſtarch is a conſtituent part, is one of the moſt important matters that can engage the attention of the chemiſt, we ſhall deſcend to a much more particular account of this than we have given of any of the other fæcula.

What is called farina, is in general a dry, friable, inſipid ſubſtance, capable of acquiring ſapidity and ſolubility by the action of fire, and conſiſting of ſeveral matters, which may be very eaſily ſeparated from one another. This ſubſtance is diſpoſed by Nature in the ſeeds of gramineous plants, eſpecially in thoſe of wheat, rye, barley, oats, rice, &c. Even leguminous plants appear to contain a compound of an analagous nature. There is, however, no other ſubſtance but the farina of wheat, which poſſeſſes all the ſame properties: none

but this farina poſſeſſes that juſt proportion of the conſtituent principles to which alone all its diſtinguiſhing properties can belong. Although the farina or flour of wheat has, from time immemorial, been uſed as a principal article of food, yet it has only within this ſhort time begun to be chemically examined. Meſſrs Beccari, an Italian phyſician, and Keſſel Meyer in Germany, are the firſt chemiſts who attempted to ſeparate the different matters of which farina conſiſts. Meſſrs Rouelle, Spielman, Malouin, Parmentier, Poulletier de la Salle, and Macquer, have proſecuted theſe reſearches a great way farther than the above-mentioned naturaliſts. M. Parmentier eſpecially has proſecuted them with very uncommon zeal and induſtry. His reſearches into the nature of theſe alimentary ſubſtances, the principles of farina, the different kinds of fæcula, and concerning nutritious vegetables in general, are undeniably the moſt complete and accurate of any thing that we have of the kind.

Water is of all agents the moſt uſeful, as it produces the leaſt alteration on the various matters with which it becomes impregnated, or which it ſeparates, according to the laws of their ſolubility. Accordingly, it is by this fluid that the different matters of which the farina of wheat conſiſts are moſt ſucceſsfully obtained ſeparate from one another. In performing this true analyſis, a paſte is firſt to be compoſed of the farina with water; the paſte muſt then be kneaded in an earthen veſſel, with water pouring upon it from a cock; the fluid, as it falls upon the paſte, takes up from it a very fine white powder, by means of which it acquires the colour and conſiſtency of milk: let this proceſs be

continued

continued till the water run off clear. The farina is now found to be naturally ſeparated into three diſtinct ſubſtances—a grey elaſtic matter that ſticks to the hand, and on account of its properties has gained the name of the glutinous, or *vegeto-animal* part,—a white powder which falls to the bottom of the water, and is the fæculum or ſtarch,—and a matter which remains diſſolved in the water, and ſeems to be a ſort of mucilaginous extract. Let us proceed to an examination of the properties of each of theſe three ſubſtances.

§ I. *Of the Glutinous Part of Wheat.*

THE glutinous part is a tenacious, ductile, elaſtic matter, of a whitiſh grey colour. It may be extended to twenty times its natural length; and it then ſeems to conſiſt of fibres or filaments, diſpoſed beſide one another in the ſame direction in which it has been drawn out. When the power by which it was extended ceaſes to act, it then returns with elaſtic force to its primary form. By drawing it out in different directions, it may be rendered ſo fine as to reſemble, in the poliſh of its ſurface, the texture of the membranes of animals. In this ſtate, it adheres with conſiderable force to dry bodies, and forms a very tenacious glue, which was uſed by ſome people for the purpoſe of re-uniting pieces of broken porcelain, long before chemiſts had found out the way of obtaining it in large quantities. M. Beccari obſerves, that in the beſt flour the proportion of the glutinous matter is from a fifth to a third part, or even more:—he remarks, too, that this proportion varies,

varies, according to the ſeaſon, and the nature of the corn.

The glutinous matter has an agreeable and ſomewhat mucous ſmell; its taſte is inſipid; it ſwells amazingly when expoſed to a ſtrength of heat ſufficient to dry it quickly. It dries very well by a moderate heat, or even in the dry air. It then becomes ſemi-tranſparent and hard, like a ſtrong glue, and, like that ſubſtance, breaks with noiſe, and with a ſmooth fracture. If, when in this ſtate, it be laid on a burning coal, or held over the flame of a taper, it exhibits all the characteriſtics of an animal matter; it crackles, ſwells, becomes liquid, is agitated, and burns in the ſame way as a feather, or a piece of horn, exhaling a ſtrong fœtid ſmell. When diſtilled in a retort, it affords, like animal matters, water impregnated with ammoniac, ammoniacal carbonate, and an empyreumatic oil: the carbonaceous reſidue is very difficult to incinerate, and is found to contain no fixed alkali.

The gluten, when expoſed freſh to a moiſt and hot air, is altered, and actually putrefied in the ſame manner as animal matters. If it ſtill retain a little ſtarch, then the ſtarch, paſſing into the ſtate of acid fermentation, retards and modifies the putrid fermentation of the gluten, and reduces it to a ſtate in which it is much like cheeſe. In this way Rouelle the younger prepared, from this gluten, a ſpecies of cheeſe, in taſte and ſmell much the ſame with Dutch cheeſe, and that of Gruyere.

Water does not at all diſſolve this glutinous matter. When boiled in that fluid, it becomes ſolid, and loſes its tenacity and elaſticity, but neither acquires a taſte, nor becomes ſoluble in the ſaliva. We may, however, obſerve,

obſerve, that to the water which was uſed in making the paſte the gluten owes its elaſticity and ſolidity. In the farina, this vegeto-animal matter, which is thus ſuſceptible of a ſolid elaſtic form, was in an incoherent and pulverulent ſtate; but when the water is poured upon the farina, and mixed with it, thoſe particles which are of a glutinous nature abſorb the fluid, and are by its means ſo cloſely united, as to form, in a ſhort time, that ſort of elaſtic ſolid which is known by the name of Gluten. Water, therefore, contributes greatly to the formation of this ſubſtance, which is perhaps to be conſidered as a peculiar compound ſaturated with water, and, for that reaſon, not capable of abſorbing any more. So true is this, that if it be deprived of its water by deſiccation, it loſes entirely its elaſtic and adheſive powers.

Moſt ſaline ſubſtances act either with more or leſs force on this gluten. Potaſh and ſoda, in a cauſtic and liquid ſtate, diſſolve it with the help of a boiling heat. The ſolution is turbid, and, on the addition of acids, depoſites gluten, which, however, is deſtitute of elaſticity.

The mineral acids diſſolve this gluten. The nitric acid diſſolves it with great activity; and M. Berthollet has obſerved, that this gluten, as well as animal ſubſtances, gives out azote gas, when expoſed to the action of the nitric acid. After the emiſſion of this elaſtic fluid, the ſolution affords a great deal of nitrous gas, and takes a yellow colour. By evaporation, it affords oxalic acid in cryſtals. The ſulphuric and the muriatic acids form, with this ſubſtance, brown or violet ſolutions. A ſort of oily matter is ſeparated from theſe ſolutions:

the gluten exiſts in them, in a real ſtate of decompoſition. M. Poulletier, who has made many experiments on this matter, has diſcovered, that from theſe combinations, diſſolved in water or alcohol, and evaporated in the open air, there may be ammoniacal ſalts obtained.

From what we have related concerning this ſubſtance, it appears, that it is entirely different from all thoſe which we have before taken notice of, as exiſting in vegetables; and that in many of its diſtinguiſhing properties, it bears a great reſemblance to the fibrous part of blood. It is to this gluten the farina of wheat owes its property of forming a tough paſte with water, and its readineſs to riſe with leaven. It appears either not to exiſt, or to exiſt only in a very ſmall proportion, in the farina of other vegetable ſubſtances, ſuch as rye, barley, buckwheat, rice, &c. all of which form ſolid, opaque paſtes, ſcarcely ductile, and brittle, and which can ſcarce be raiſed when expoſed to the ſame temperature by which paſte of the farina of wheat is raiſed. No other ſubſtance but flour of wheat, therefore, is poſſeſſed of all the qualities neceſſary for making good bread.

M. Berthollet is of opinion, that this glutinous ſubſtance, like animal matters, contains phoſphoric ſalts, which are the occaſion of its coal being ſo difficult to incinerate. Rouelle the younger has diſcovered a glutinous ſubſtance, reſembling that of the farina of wheat, in the green fæcula of plants, which afford, by analyſis, ammoniacal carbonate and empyreumatic oil, like the vegeto-animal matter of which we have been ſpeaking

§ II.

§ II. *Of the Starch of Wheat.*

STARCH, the amylaceous fæculum, is the moſt copious part of the farina. This is the ſubſtance which is carried off, and afterwards precipitated from the water with which the paſte is waſhed, in order to obtain the pure gluten. This ſubſtance is very fine, feels ſoft, and has no perceptible taſte. Its colour, when it is extracted by the proceſs above deſcribed, is a dirty grey-white; but the manufacturers of ſtarch render it exceedingly white, by ſteeping it in an acid water, which they call *ſour water*. It appears, from the experiments of M. Poulletier, that the fermentation which takes place in that fluid whitens and purifies the ſtarch, by attenuating, and even deſtroying, the extractive mucous ſubſtance which is precipitated with it in the firſt waſhing. Starch, chemically conſidered, is a mucilage of a peculiar nature. This mucilage, which by ſome chemiſts has been miſtaken for an earth, is very different from the gluten. It does not, like the gluten, diffuſe an empyreumatic ſmell when it burns. When diſtilled by naked fire, it affords an acid phlegm, of a brown colour, and, towards the concluſion of the proceſs, a very thick empyreumatic oil. The coaly reſidue is eaſily enough incinerated; and its aſhes are found to contain fixed alkali.

Starch is not ſoluble in cold water; but when boiled in water, it forms with the fluid a glue, or rather what in French is demoninated by the peculiar name of *empois*. This compound, when expoſed to damp air, loſes

by degrees its conſiſtency, ferments, becomes ſour, and is covered over with mouldineſs.

The nitric acid affords, with this fæculum, oxalic acid, perfectly the ſame with that of which we have ſpoken in the foregoing chapter.

As ſtarch forms the greateſt part of flour, there can be no doubt of its being the principal alimentary ſubſtance contained both in flour and in bread.

§ III. *Of the Extractive Mucilaginous Part of the Farina.*

BY evaporating the clear water that had been uſed in waſhing the paſte, and had depoſited the ſtarch, M. Poulletier obtained a viſcous, adheſive matter, of a brown-yellow colour, the taſte of which was faintly ſaccharine. This ſubſtance, to which he gave the name of *mucoſo-ſaccharine*, diſplayed, in combuſtion and diſtillation, all the ſame phænomena with ſugar. By it the acid fermentation is produced in the water which ſwims over ſtarch; for, as Macquer has obſerved, ſtarch is not at all ſoluble in cold water. The mucoſo-ſaccharine matter exiſts in the farina of wheat only in a very ſmall proportion. It may poſſibly be more copious in the farina of ſome other vegetable ſubſtances.

However ſmall the proportion of this ſubſtance in the farina of wheat, yet there can be no doubt of its acting a peculiar part in the fermentation which takes place in paſte, and cauſes it to riſe. The nature of this motion, ſo neceſſary to render bread wholeſome, is ſtill but very little known. It would appear to be nothing more but the

the beginning of a putrid fermentation in the gluten, an acid fermentation in the ſtarch, and perhaps a ſpiritous fermentation in the mucoſo-ſaccharine matter. Theſe three incipient fermentations, which mutually oppoſe each other, are perhaps what produces the compound, ſo much lighter than dough, which, by baking, and a proper expoſure to heat, forms bread. One thing certain is, that in bread all the three ſubſtances which we have here examined, are found exiſting together, but ſo much altered, that they can no longer be extracted ſeparately. Even the action of heat alone, without the motion of fermentation, is ſufficient to change the nature of theſe three ſubſtances, and combine them in ſuch a manner, that even from bread, unleavened, or baked without being raiſed, Malouin and M. Poulletier tells us, the gluten can no longer be obtained.

From theſe particulars, we underſtand how that all flour but that of wheat, and ſtill more the leguminous or farinaceous ſeeds, ſuch as beans, peaſe, cheſnuts, &c. are far from poſſeſſing the qualities requiſite for making good bread.

CHAP.

CHAP. XVIII.

Of Vegetable Colouring Matters, and their Application to the Art of Dyeing.

VEGETABLES contain colouring matters through all their organs. Theſe matters are extremely various. It often happens, that a vegetable matter, which has of itſelf no apparent colour, aſſumes a very diſtinct one when expoſed to the action of certain menſtrua. The art of dyeing, all the proceſſes of which are entirely chemical, is founded on the knowledge of the ſolubility of theſe colouring parts of vegetables, in various menſtrua,—of the way of applying them, ſo as to communicate colour to other ſubſtances,—and of rendering them permanent and tenacious on thoſe ſubſtances. In examining the properties of each of the colouring matters, we will have occaſion to give ſome account of the principles of this important art, on which Meſſrs Hellôt, Macquer, le Pilcur d' Apligny,

Hecquet d'Orval, and the Abbé Mazéas, have already publiſhed excellent works.

It appears that the colouring matter of vegetables, properly ſo called, is ſtill unknown. Rouelle was of opinion, that the green part, ſo copious in the vegetable kingdom, was ſimilar in nature to the gluten of the farina. But it is certain, that this matter exhibits different chemical characteriſtics, according to the diverſity of the baſes with which it is united. It is therefore rather the baſe than the colouring part itſelf of which we ſpeak, when we ſay, ſuch a colour is extractive, and ſuch another colour reſinous, &c. The ſubſtance which really colours thoſe parts of vegetables that are employed in the arts is no doubt a very ſubtle body, perhaps not leſs ſo than the principle of ſmells. There is even ſome reaſon to think, that it conſiſts ſolely in a certain modification of the ſolid and liquid parts of vegetables.

It may be proper to recollect here, that the colouring of vegetables depends, in a great meaſure, on the contact of light. But in what manner the contact of light contributes to the production of colours, is a problem of which the reſearches of the natural philoſopher have as yet afforded no ſolution. However that may be, as it is impoſſible to ſeparate the colouring matter entirely from the vegetable baſe to which it is united, it is generally agreed to conſider theſe two ſubſtances together as the colouring matter of plants.

Of all chemiſts, Macquer has beſt diſtinguiſhed the nature of the different colouring matters of vegetables, conſidered with reſpect to the art of dyeing: And his theory concerning the application and the fixation

of colours on other ſubſtances in dyeing, is beyond a doubt the moſt ſatisfactory. As I intend here to connect this theory of dyeing with the hiſtory of the chemical properties of the colouring parts of vegetables, I ſhall begin with the conſideration of thoſe properties.

1. A great many vegetable colouring matters, which are either extractive or ſaponaceous, diſſolve very readily in water. Baſtard rocket, madder, logwood, redwood, and Braſil wood, afford yellow or red colours of this ſort. It is eaſy to ſee, that matters dyed with theſe colours muſt loſe their dye in water: on this account, there is employed, to render theſe colours permanent, ſome additional matter capable of fixing and decompoſing them; ſuch as crude tartar, alum, and other ſalts. Theſe ſalts are called *mordants*. A ſolitary acid might produce the ſame effect; but would alter the colouring matter. The ſuperfluous portion of the acid of the alum combines with the alkali of the ſaponaceous colouring extract, and occaſions the precipitation of the reſinous part of that extract, which is then inſoluble in water, upon the ſubſtance intended to be dyed. This colouring part, however, which is rendered inſoluble by the alum, or the mordant, is of two kinds. The firſt is very ſolid, and reſiſts the action of air, of ſoaps, and of all the liquors uſed by dyers as proofs. The other is liable to be altered by air, and ſtill more by the proof-liquors: it is called a falſe dye. In order to aſcertain the nature of theſe colours, and the durability of dyes in general, M. Berthollet has propoſed the uſe of the oxigenated muriatic acid. This acid effects, in a very ſhort time, by means of its exceſs of oxigene, what the vital air of

the

the atmoſphere takes a long courſe of time to accompliſh: And, by obſerving what quantity of this acid is neceſſary to diſcolour and entirely whiten any died ſtuff, as well as the time which it takes to produce the effect, a judgment may be formed of the ſolidity and the durability of the colours thus ſubmitted to examination.

It is to be obſerved, that wool takes a dye better than any other ſubſtance; and next after wool, ſilk, cotton, and flax, in the order in which they are here mentioned, receive a dye, each of them with more difficulty than the preceding one, and loſe it ſooner.

Thoſe authors who have written upon the art of dyeing have maintained different opinions concerning the way in which colouring matters act on the ſubſtances expoſed to their operation. Many have ſuppoſed, that in proportion as the pores of the ſubſtance to be dyed are more or fewer, greater or ſmaller, the colouring matter is more or leſs completely applied to it; and that the reaſon why wool takes a colour better than ſilk or thread is, becauſe its pores are more open and more numerous than thoſe of either of theſe ſubſtances. But Macquer thinks the true cauſe which renders the application to any ſubſtance more or leſs eaſy, is the relation between the colouring matter and the body to be died, being nearer or more remote. Dyeing, in his opinion, is actually nothing but painting, which ſucceeds and laſts only by virtue of an intimate affinity between the colouring matter and the dyed ſubſtance. That celebrated chemiſt adopted this opinion in conſequence of the numerous experiments which he made in the art of dyeing; which is indeed highly indebted to his diſcoveries.

2. There is another claſs of colouring matters, which ſeem to conſiſt of reſin and ſaponaceous extract. Macquer calls them *reſino-terreous* matters. When theſe matters are boiled in water, the reſinous ſubſtance which they contain is melted, and diffuſed through the fluid, by means of the action of the heat, and the ſolution of the ſaponaceous part: but it is precipitated as the bath or decoction cools. When, therefore, wool, or any other matter, is immerſed in a decoction of mixed colouring matter of this kind, the reſin is ſeparated by cooling; and, without requiring any farther proceſs, fixes on the ſubſtance thus expoſed to it. Not being ſoluble in water, it forms a permanent dye. Colouring matters of this kind are obtained from almoſt all aſtringent vegetables, ſuch as the huſks of nuts, the roots of the walnut-tree, or of dock, ſumach, bark of alder, ſandal wood, &c. Theſe colours are all yellow, and are called by the dyers root-colours. They are generally uſed to form a good ground, on which colours of a higher luſtre may be laid. We may further remark, that the colouring matters, for the application of which no particular preparation, either of themſelves, or of the bodies to which they are applied, is requiſite, afford the ſimpleſt tincture, and are the eaſieſt applied to uſe.

3. The colouring principle of various other ſubſtances exiſts in a matter that is purely reſinous, and inſoluble in water. Several of theſe matters are not ſoluble even in alcohol; but in alkalis they are all diſſolved, and reduced into a ſort of ſaponaceous ſtate, in which they are ſoluble in water.—The following are the principal colours of this ſort uſed in dyeing.

A. The annatto, a kind of fæculum obtained by maceration from the ſeeds of the *urucu* putrefied in water. This fæculum is depoſited during the putrefaction of the ſubſtances. It is at firſt red, but in courſe of time becomes of a brick-duſt colour. Stuffs intended to be dyed with this matter are immerſed into a lixivium of this paſte, with the *cendres gravelees*, which we are ſhortly to deſcribe, mixed together in water. Without the aſſiſtance of any mordant, there is depoſited on the ſubſtances immerſed into this lixivium a golden yellow, or orange colour, of conſiderable beauty.

B. The flower of carthamus, or baſtard ſaffron, affords, by the ſame proceſs, a very beautiful red colour. This flower has two different colouring parts; the one purely extractive, and ſoluble in water; the other reſinous.—To obtain the latter, the ſoluble part of the carthamus muſt firſt be carefully waſhed away: What remains after the waſhing muſt be mixed with the *cendres gravelees*, or ſoda; this mixture is then to be formed into a lixivium, and employed in dyeing. But as the alkali alters the colouring matter, and tarniſhes the colour, the dyed ſubſtance is ſteeped in water, acidified by lemon-juice. This acid ſeizing the alkali, the colouring matter is left at liberty, in conſequence of which it regains its original properties, and becomes red. By a ſimilar proceſs, there is a coloured fæculum obtained from carthamus, which, mixed with briancon-chalk in powder, compoſes the *rouge* made uſe of by the ladies.

C. Archil is a paſte prepared from inoſs and lichen, macerated in urine, with lime. The lime diſengages the volatile alkali; and this cauſes the red colour to appear. Archil diluted in water communicates a dye without any

other preparation. It gives a violet colour; but this is a falſe dye, which is altered in the air, and rendered yellow by the action of acids

D. Indigo, thecolour of which is a deep violet blue, ſeemingly of a cupreous nature, is a fæculum prepared at St Domingo, and in all the Antilles, &c. by macerating the ſtalk of the *anuillo*, or indigo plant, in ſtone troughs, with water. The water becomes blue; and, after it has been for ſome time violently ſtirred, the fæculum is precipitated. The indigo ſeparated from the water is put into cloths to drain. It is then dried in ſmall wooden boxes, and when dry broken into pieces. When it floats on water, and burns entirely away on a red-hot ſhovel, it is eſteemed good. The colouring part of it is extracted by alkalis, and applied to the matters intended to be dyed, without any farther preparation. It cannot be brightened by acids, as theſe would alter the colour.

4. There are certain colouring matters ſoluble in oils. Alkanet, or the red root of a ſort of bugloſs, communicates its colour to oil. Alcohol likewiſe diſſolves ſeveral colouring matters: Green fæcula diſſolve in it as well as in oil. It may be eaſily underſtood, that theſe colours cannot be uſed in dyeing, becauſe the liquids neceſſary to extract them cannot be employed.

Such are the principal facts at preſent known concerning the nature of vegetable colours. From theſe it appears, that any of the immediate principles of vegetables may become the baſe of their colouring parts; as we find them to be ſaponaceous, reſinous, and extractive. Some of them even appear to be of the ſame nature with fixed oils, and are not ſoluble either in water or in alcohol, but diſſolve readily enough in alkali. Laſtly,

There

There are, according to Rouelle, ſome of theſe colouring parts of the ſame nature with the glutinous part of vegetables.

All vegetable colouring matters poſſeſs a more or leſs powerful attraction for oxigene. There are few of them that do not experience a more or leſs ſudden alteration from this principle. The oxigenated muriatic acid alters almoſt the whole of them, and converts them into white or yellow. Moſt part of vegetable colours contain different proportions of oxigene, and frequently owe their ſhades to a difference in the quantity of this principle. This is the reaſon why all theſe colours are prepared with the contact of air, becauſe this contact has a ſingular effect upon their dyes. See M. Hauſeman's Memoir upon indigo (*Journal de Phyſique*, 1788), and my Memoir on the colouring of vegetables by oxigene. Annals of Chemiſtry, Vol. IV.

CHAP. XIX.

Of the Analyſis of Plants by Naked Fire.

AFTER examining all the matters which can be obtained from vegetables, by ſuch ſimple means as produce no alteration in their nature, and conſidering theſe matters as the immediate principles of thoſe organized bodies, it will next be proper to conſider what alterations they are liable to ſuffer from fire.

The ancient chemiſts were acquainted with no other method of analyſing vegetables but this; and all their inquiries into the nature of theſe ſubſtances were directed only to diſcover, how much ſpirit, oil, and volatile ſalt, they afforded by diſtillation in the retort. At preſent we give but little credit to the reſults of this proceſs.—We know, that all plants give nearly the ſame products; and the diſtillation of a great many different vegetables, by chemiſts in other reſpects very ſkilful and highly reſpectable, has only ſerved to undeceive us with reſpect to this analyſis. How, indeed, can it be thought, that the action of fire, which is exerted on all the diſ-

ferent

ferent principles contained in a vegetable, extract, mucilage, oil, reſin, ſaline matter, gluten, &c. and which decompoſes each of them in a peculiar manner, can afford any certain information concerning the nature and the quantity of thoſe principles? eſpecially when we obſerve, that the products of theſe different decompoſitions form, by mutual combination, new bodies, which did not exiſt before in the vegetable under examination. The analyſis of vegetables in the retort is therefore falſe and complicated.

However, as, in a chemical examination of any ſubſtance, we ſhould not refuſe the uſe of any means which art ſupplies for the diſcovery of its nature, we may have recourſe to this analyſis, and obſerve its effects, provided we be ſufficiently on our guard againſt giving too much credit to its reſults: Nay, it ſometimes happens, that when, in a ſeries of experiments on any vegetable ſubſtance, in order to diſcover its chemical properties, we compare the effects of aqueous, ſpiritous, and oily menſtrua on that ſubſtance, with the alterations which it ſuffers from fire, theſe alterations accord with the action of the ſolvents, and ſhew, by the products of the diſtillation, what matter is contained in a larger or a ſmaller quantity in the vegetable, the nature of its ſalt, &c. But, that we may be able to make ſuch important deductions from an analyſis by naked fire, it is requiſite, 1. That we be well acquainted with the manner in which fire acts on each of the immediate or proximate principles of vegetables, the extract, the mucilage, the ſaline matter, the oily juices, fluid or dry, &c. 2. That we compare the products of the diſtillation of the whole vegetable with thoſe which its proximate principles general-

ly

ly afford when treated in the ſame manner. 3. That we, at the ſame time, analyſe the vegetable by menſtrua, in order that we may diſtinguiſh its proximate principles, and draw ſome uſeful inferences concerning the alterations which it ſuffers from fire.

The proceſs neceſſary for the diſtillation of vegetables by naked fire, is very eaſy and very ſimple.—Put into a glaſs or earthen retort a certain quantity of the dry vegetable :—care muſt be taken, however, to fill the veſſel only half, or not more than two thirds full. Place the retort in a reverberatory furnace; to its neck adapt a balloon of a proper ſize. There uſed to be formerly recommended for this purpoſe, a balloon perforated with a ſmall hole, to afford a paſſage for the air which was ſaid to be diſengaged, in a ſmaller or a larger quantity, from the vegetables, and was likely, if confined, to break the veſſels. At preſent we know, that the aeriform fluid which eſcapes from theſe bodies, when ſubjected to diſtillation, is never air, but rather carbonic acid and hydrogenous gas, with carbonaceous matter diſſolved in them. But as theſe elaſtic fluids are products of the vegetable, decompoſed by the action of fire, as well as the phlegm, the oils, and the volatile ſalts, it is no leſs neceſſary to collect them than theſe latter ſubſtances. For this purpoſe, there may be employed a perforated receiver, joined to a curved ſyphon, entering by one end into a bell-glaſs filled with water, or rather with mercury. By this means, the liquid products are collected into the receiver, and the aeriform products into glaſs veſſels, placed on the ſhelf of a pneumato-chemical apparatus. When the ſubſtance diſtilled is ſuch

as

as can afford any concrete ſalt, there is put between the retort and the receiver an adapter, or long glaſs veſſel, in the form of a ſpindle, on the ſides of which the ſalt fixes as it is ſublimated. In this ſort of diſtillation, the fire ſhould be gradually and cautiouſly applied, that the products may be obtained in the order of their volatility, without being confounded together. The proceſs begins with placing a few coals under the retort, and the fire is by degrees increaſed till the veſſel become red-hot, and the paſſing of the products into the receiver appear to have ceaſed. The retort is now ſuffered to cool, the luting removed from the apparatus, and the products examined.

Although the products obtained by the diſtillation of vegetables are never to be entirely depended upon, yet ſo much do they differ from one another, that they well deſerve to be carefully diſtinguiſhed.

The firſt product obtained is an aqueous liquor, impregnated with ſome odorous and ſaline principles. This phlegm aſſumes by degrees more colour, and more ſaline properties. After it, comes a coloured oil, the colour of which becomes deeper, as the proceſs advances. This oil is ſometimes light and fluid, at other times weighty, and liable to become ſolid. It conſtantly exhales a ſtrong empyreumatic ſmell. At the ſame time with it, there is a ſmaller or a greater quantity of elaſtic fluids diſengaged; which are either carbonic acid, or hydrogenous gas, or, which is moſt frequently the caſe, a mixture of theſe two ſubſtances. At the ſame inſtant, too, ammoniacal carbonate is ſublimated, if the nature of the vegetable be ſuch as to afford it. After all theſe matters

have

have paſſed, the vegetable is found reduced to a carbonaceous ſtate. Let us now return to a more particular examination of each of theſe products, and attempt to diſtinguiſh what is their nature, and to what ſubſtances they owe their formation.

The phlegm, according to the ancient chemiſts, is owing to the water which enters into the compoſition of the vegetable, and in part to the water of its vegetation; and this eſpecially, when the body analyſed is not entirely dry: and accordingly the quantity of this phlegm is greater or leſs in proportion as the vegetable has been more or leſs thoroughly dried before it was ſubmitted to diſtillation. Several modern chemiſts are of opinion, that the water obtained from the diſtillation of vegetables is formed by the union of hydrogene with the oxigene contained in theſe organized ſubſtances. This phlegm is coloured of a lighter or a deeper red by the ſmall portion of oily matter which it carries off with it, and which is reduced to a ſaponaceous ſtate by the ſalt that is uſually diſſolved in it. The ſaline matter in union with it is moſt commonly acid; on which account this phlegm uſually reddens ſyrup of violets, and produces an effervescence with alkaline carbonates. This acid belongs to the mucilages and oils. The phlegm is ſometimes of an alkaline nature, as in the diſtillation of nitrous and cruciform plants, and of emulſive and farinaceous ſeeds. It is frequently ammoniacal; becauſe the ammoniac which follows immediately after the acid combines with it. Of this fact full evidence may be obtained, by throwing a little fixed alkali or quick-

lime

lime into the phlegm: When it is ammoniacal, there is a lively ſmell of ammoniac diſengaged from it.

The oils obtained from vegetables by diſtillation in a retort are all ſtrong-ſmelling and high-coloured, and exhibit all of them nearly the ſame properties. Thoſe parts of vegetables which contain a great quantity of theſe inflammable fluids, ſuch as emulſive ſeeds, afford, when analyſed, a good deal of oil. The odorous plants afford an oil, which, in the beginning of the proceſs of diſtillation, retains ſomewhat of their ſmell, but ſoon aſſumes the common characteriſtics of all theſe oils; that is to ſay, the colour, gravity, and empyreumatic ſmell, by which they are diſtinguiſhed. All of theſe fluids are highly inflammable; the nitrous acid cauſes them to flame: they are ſoluble in alcohol, and bear, all of them, ſome reſemblance to the vegetable from which they were obtained. By rectification, they may all be rendered very fluid, very light, colourleſs, ſoluble in alcohol; in a word, they may thus be reduced to the ſtate of æthereal or volatile oils.

Theſe empyreumatic oils are formed by the action of the fire, and had no previous exiſtence in the vegetable.

With reſpect to the volatile ſalt, which is nothing but ammoniacal carbonate, it is obtained only from a few vegetables; but we muſt not imagine, as has been advanced by ſome chemiſts, that it is to be obtained only from cruciform plants. All plants, in general, containing a certain quantity of glutinous or vegeto-animal matter, afford more or leſs ammoniac; becauſe, as has been fully proved by M. Berthollet, that principle of

vegetables

vegetables always contains azote. It very ſeldom happens, however, that any quantity of it can be obtained in a concrete ſtate: it is often diſſolved in the laſt portions of the phlegm. This ſalt is produced by the union of the azote with the hydrogene of the oil; on which account, it does not uſually paſs till the end of the diſtillation. It even appears, that what is carried up by the phlegm in the analyſis of ſome plants, ſuch as the cruciferous plants, poppy, rue, &c. is always the product of ſome new combination; for Rouelle the younger has ſhewn, that the plants themſelves do not contain it in their natural ſtate.

The elaſtic fluids which are diſengaged during the diſtillation of vegetables, are to be included among the products that may be obtained from them. Their nature appears to depend on the nature of the vegetable. A plant which contains a good deal of oily combuſtible fluids, affords hydrogenous gas. Mucilages, on the contrary, afford carbonic acid. We have mentioned, under the article Oxalic Acid, that Meſſrs Bergman and Fontana have obtained from them a large quantity of carbonic acid, and that Fontana thinks vegetable acid to be compoſed chiefly of it. It is therefore not at all ſurpriſing, that mucilages, in which Bergman found the ſame radical acid as in ſugar, ſhould afford carbonic gas when analyſed. Laſtly, There are ſome vegetable matters which afford azotic gas. Theſe aeriform fluids paſs only towards the end of the proceſs of diſtillation; becauſe they are not diſengaged till the inſtant when the vegetable is totally decompoſed. Hales, who was not acquainted with their nature, obſerved, that the more

more ſolid the vegetable, ſo much the greater was the quantity of the air diſengaged from it during its diſtillation: and he of conſequence conſidered that element as the cement which produced the ſolidity of vegetable bodies. From what we have had occaſion to ſhew, the reader may eaſily judge of the truth of this hypotheſis.

CHAP.

CHAP. XX.

Of Vegetable Coal, or Charcoal.

CHARCOAL is the black reſidue of vegetable matters, whoſe volatile principles have been entirely decompoſed in cloſe veſſels. None but organic matters, containing the combuſtible ſubſtance known by the name of oil, afford charcoal. The production of the ſubſtance which we are beginning to conſider, uſed to be aſcribed to the decompoſition of this latter ſubſtance; but it is now beginning to be underſtood as a fact, that the carbonaceous matter exiſts ready formed in the vegetable; and that which is accompliſhed by the operation of fire, is the ſeparation of the volatile principles that exiſted in union with it.

Charcoal is generally black, brittle, ſonorous, and light. If the vegetable of which it has been formed was very compact, and contained but a ſmall proportion of fluid ſubſtance, it ſtill retains a vegetable form. But again, when the plant decompoſed is tender, and contains

a good deal of juice, the fluids, as they are diſengaged, deſtroy the organic texture of the vegetable, and leave a friable coal, which exhibits not the form of a decompoſed vegetable. Different vegetable matters afford coal in greater or leſs abundance, according to the ſolidity, and the form of their texture. Wood affords much more of this ſubſtance than herbs; gums afford more than reſins; and reſins more than fluid oils. Every different vegetable matter appears to contain this ſubſtance in a particular proportion,—if we conſider charcoal as one of the immediate principles of vegetables.

Charcoal is a body poſſeſſed of ſingular properties, which are in general but very little known.—Though it be of the higheſt importance in chemiſtry, and exhibit phænomena entirely of a ſingular nature, yet no chemiſt has as yet engaged in a ſeries of experiments with a view to aſcertain its nature. Stahl, who paid more attention to it than it has ſince obtained from any other perſon, thought it the principal repoſitory of phlogiſton. We know ſcarce any thing concerning the properties of charcoal, but what relates to the œconomical purpoſes to which it is applied: the labours of the learned afford no full information concerning it.

The phyſical properties of charcoal are different, according to the nature and the ſtate of the vegetables from which it is formed. It is ſometimes hard, and retains in ſome degree the organization of the vegetable; at other times it is friable, and ſomewhat pulverulent. Pure oils afford a coal in very fine, and ſeemingly levigated molecules, called lamp-black. Its gravity varies in like manner. When well made, it has no perceptible

taſte or ſmell. Its colour is ſubject to as many varieties as its other phyſical properties; it is either of a lighter or a deeper, a ſparkling or a dull colour. But the chemical properties of this product of fire, deſerve the moſt particular examination.

Charcoal expoſed in cloſe veſſels to the utmoſt violence of fire, ſuffers no alteration. When heated in a pneumato-chemical machine, it affords no hydrogenous gas, unleſs it happen to contain moiſture: an intenſe heat reduces it to vapours. When heated in contact with air, it burns it to aſhes; but with ſingular phænomena, which are to be carefully diſtinguiſhed from thoſe of other combuſtible matters. As ſoon as it takes fire, it becomes red, and exhibits a white flame, which is more conſiderable in proportion as the maſs of charcoal is larger. No ſort of ſmoke exhales from it; but it is reduced into carbonic acid, an elaſtic fluid, which, from the fine experiments of M. Lavoiſier, appears to be nothing but a combination of the carbonaceous principle with the oxigenous—of the latter of which principles three fourths of it conſiſt. It is on this account that charcoal conſumes ſlowly, and leaves nothing but a cinder, more or leſs white, partly of a ſaline, and partly of an earthy nature. Different ſorts of charcoal are of different degrees of inflammability; and this diſtinction is the moſt uſeful to the arts of all the facts reſpecting charcoal. Some ſorts of it burn readily with flame, and are quickly conſumed; others are difficult to kindle, burn but ſlowly, and remain a long time red-hot, before being reduced to aſhes. Some of them,—for inſtance thoſe of oils,—burn indeed, but with the utmoſt difficulty. This property they ſeem to owe to the obſtinate

ſtinate adheſion of the carbonaceous principle to the fixed ſalts of the vegetables; and as the proportion of theſe laſt varies in each vegetable, the denſity of the charcoal, and the quantity of reſidue which it leaves after combuſtion, depend on this cauſe.

Charcoal, when expoſed to the air, attracts moiſture; probably becauſe it is very porous; and perhaps, too, on account of its containing ſalts, though theſe ſalts be not in a diſengaged ſtate. When moiſtened, it affords hydrogenous gas, which is produced by the decompoſition of the water: for, when this fluid is paſſed through an earthen tube, filled with red-hot charcoal, the two bodies are converted into hydrogenous gas and aeriform carbonic acid. Nothing now remains but a little aſhes. Rouelle has taken notice, that fixed alkali diſſolves a pretty conſiderable quantity of charcoal by fuſion.

The ſulphuric acid, when expoſed to a ſtrong heat with powder of charcoal, is decompoſed by this combuſtible body, which has a ſtronger affinity with oxigene than ſulphur has.

The nitric acid is decompoſed with much more rapidity by charcoal. Dr Prieſtley obſerved, that there was a good deal of nitrous gas produced from this mixture. Macquer ſaw the nitric acid, with the help of a certain degree of heat, produce a very diſcernible efferveſcence with this body. M. Prouſt has ſucceeded in kindling charcoal with acid of nitre, the weight of which was one ounce four drams and twenty-three grains, in a bottle containing an ounce of diſtilled water. The reſult of his experiments is of no ſmall importance: And I ſhall therefore here inſert an account of them in his own words, taken from his Obſervations on Pyrophori

without alum, &c. inſerted in the *Journal de Medicine*, for July 1778.

" A coal of the extract of carthamus, reduced to " powder, and newly calcined, detonized in a very lively " manner with the nitrous acid; and the combuſtion " was ſo rapid, as to raiſe the powder in the form of a " very beautiful ſky-rocket. I calcined, likewiſe, very " fine powder of common charcoal; and the detonation " ſucceeded very well.

" Into a glaſs retort, perfectly dry, I introduced about " a dram of powder of charcoal; after which I poured " into the ſame retort about as much nitrous acid: " the nitrous acid no ſooner reached the bottom of the " retort, than a detonation was produced with the ut- " moſt rapidity. There proceeded out of the mouth of " the retort, as I held it in my hand, a ſtream of flame, " more than four inches in length, carrying with it " ſome of the powder, and very dark-coloured vapours " of the nitrous acid: The vapours were condenſed in- " to a green and ſomewhat ſuming liquor, which pro- " ved to be nitrous acid, weakened by the water which " entered into the compoſition of that which detonized " firſt. I poured a new quantity of nitrous acid on the " coal which ſtill remained in the retort, and continued " to inflame it in the ſame way, till the whole quantity " was exhauſted.

" This experiment I repeated with calcined lamp- " black; the ſame phænomena were exhibited. In the " retort there remained only a very ſmall portion of " aſhes, ſometimes half vitrified, and ſticking to the bot- " tom of the retort.

" All

" All charcoal is uſually impregnated with a conſider-
" able quantity of moiſture. I found that charcoal cal-
" cined in the evening was next day unfit for this de-
" tonation, having acquired, during the intervening ſpace,
" a ſenſible quantity of moiſture. But, what is very
" ſingular, theſe experiments are ſo capricious, that they
" do not always ſucceed, even with the ſame charcoal,
" and the ſame acid, intermixed in the very ſame pro-
" portions. By the following expedient, I believe, ſuc-
" ceſs may be ſecured: When the acid is poured on
" the middle of the charcoal, it does not take fire at all;
" but, again, when the acid is made to trickle down the
" ſides of the crucible or capſule, till it reach the bot-
" tom, then detonation infallibly follows, and the pow-
" der is raiſed and kindled by the nitrous acid. When
" the nitrous acid is all conſumed, the detonation
" ceaſes of courſe, and the reſt of the charcoal remains
" black."

We know nothing concerning the action of the other acids on charcoal.

This body, with the help of heat, decompoſes all ſulphuric ſalts, forming in conſequence ſulphures with various baſes.

Charcoal cauſes nitre to detonize; the nitre burns it by means of the vital air which this ſaline ſubſtance affords by the action of fire. There is a preparation made for the purpoſes of chemiſtry and pharmacy, which is called *nitre fixed by charcoal.* Mix two parts of nitre with one of powder of charcoal; put the mixture into a red-hot crucible: A lively detonation immediately takes place: And, when this detonation ceaſes, there

remains a white maſs, which attracts moiſture from the atmoſphere, and is nothing elſe but the fixed alkali of the nitre and the charcoal combined with carbonic acid. On lixiviating this matter, the water diſſolves the fixed alkali; and what remains is a ſubſtance thought to be of an earthy nature.

Sulphure of potaſh diſſolves charcoal with great facility, both by the dry and by the humid way: it even combines with it more readily than any other ſubſtance. We owe this diſcovery to Rouelle.

Metals do not combine with charcoal; but metallic oxides are reduced, when expoſed in contact with this body, to heat more or leſs intenſe. We have already ſeen, under the article of Metals, that this phænomenon is owing to the ſtrong affinity between oxigene and pure carbonaceous matter.

The action of vegetable ſubſtances on charcoal has been but little examined. We know only, that charcoal mixed with fat oils, renders them ſuſceptible of inflammation by the nitrous acid; a fact which confirms Rouelle's beautiful theory concerning the inflammation of oils by that acid.

Within theſe few years, charcoal has been alledged to be very proper for whitening and purifying vegetable liquors, when heated along with them.

All that has been here ſaid concerning the known properties of charcoal, tends to prove that this body is a compound of a combuſtible matter, ſaline ſubſtances, and earths.

The peculiar combuſtible matter which conſtitutes more than three fourths of the compoſition of charcoal,

or pure carbonaceous matter, is but little known. It appears only to be one of thoſe bodies which have the greateſt affinity with oxigene; ſo great indeed, that it is capable of ſeparating it from every other ſubſtance; and that, in certain circumſtances, it exhibits properties much the ſame with thoſe of native *carbure* of iron.

The uſes of charcoal in the arts are ſufficiently known; it is likewiſe of great uſe in chemical operations.

CHAP. XXI.

Of the Fixed Salts and Earths of Vegetables.

WHEN a vegetable coal is burnt, there remains a grey, blackiſh, or white matter, according to the nature of the coal. This ſubſtance, which is called *aſhes*, is of a very compound nature. When the charcoal is thoroughly burnt, it contains only different ſaline and earthy ſubſtances, mixed with a little iron and a little manganeſe. When, again, the charcoal does not burn very freely, the aſhes produced from it ſometimes contain a little inflammable matter which has not been conſumed. M. Lavoiſier, on examining the aſhes of the wood made uſe of by the manufacturers of ſaltpetre, found it to contain extractive and reſino-extractive matters. The ſaline ſubſtances obtained by lixiviation from the aſhes of charcoal, have received the name of the Fixed Salts of Plants. There are three ſorts of ſalts obtained by the incineration of vegetables, the nature of which we ſhall here deſcribe.

1. Potaſh, which is prepared in the north by burning wood, which they there poſſeſs in great plenty. This ſalt is very impure; it often contains combuſtible matters by which its whiteneſs is impaired, a variety of neutral ſalts, ſuch as ſulphate of potaſh ſoda and lime, muriate of potaſh and of ſoda, a little carbonate of ſoda, oxide of iron, and earthy matters. To purify this ſalt, and extract from it pure potaſh, it is diſſolved in the ſmalleſt poſſible quantity of cold water. The fluid takes up the alkali, with ſome neutral ſalts; and the earth, charcoal, iron, and ſulphate of lime which the potaſh frequently contains, are ſeparated by filtration. The ſolution is evaporated to a pellicle, and then ſuffered to ſettle and cool, in order that the different neutral ſalts which it contains may be formed into cryſtals. When, at length, after repeated filtration, evaporation, and cryſtallization, the lixivium ceaſes to afford neutral ſalts, it is evaporated to dryneſs, and calcined. The ſalt thus obtained is carbonate of potaſh, intermixed with cauſtic potaſh. It always contains, however, ſome neutral ſalts, and a ſmall portion of earthy matters, which may be ſeparated by forming theſe ſalts and earthy matters into a ſtrong ſolution with water, ſuffering that ſolution to ſettle and reſt for ſome time, and then ſeparating, by filtration, the ſediment thus formed. The potaſh may now be uſed with confidence as pure, even in the niceſt chemical experiments.

2. Soda is the reſidue remaining after the combuſtion of certain plants which grow on the ſea-ſhore. It is prepared at Alicant, in Languedoc, at Cherbourg, &c. by the combuſtion of various plants. At Alicant, the kali is employed; at Cherbourg, the algas and fucus, commonly known by the name of *varech*. The former

former of theſe plants contains a good deal more ſoda than the other; which indeed affords but very little. Theſe plants are made very dry, and burnt over a trench. At Cherbourg, when the combuſtion is conſiderably advanced, and the aſhes are become very hot, they are violently ſtirred and kneaded together with large poles. By this motion, the ſubſtance, being hot enough to ſuffer a ſort of ſemi-vitrification, is formed into ſolid, hard pieces, which are ſold in commerce under the names of *ſtone-ſoda*, *ſalicore*, *ſalicote*, *la marie*, and *alun catin*. The names by which it is chiefly diſtinguiſhed, and which denote its particular ſtate, are thoſe either of the country from which it comes, or the plant from which it is obtained. The ſoda of Alicant, called alſo *barilla*, is the beſt for the purpoſes of chemiſtry, and of all thoſe arts in which fixed alkali is neceſſary.

The ſoda of Cherbourg, or *varech*, contains leſs alkali, and ſhould not be uſed in chemiſtry; but in glaſs-works it is very advantageouſly employed; for it contains vitreous frit, which anſwers the purpoſes of the glaſs-maker, by promoting the vitrification of the other matters.

Common ſoda, chemically conſidered, is a compound of cauſtic ſoda, carbonate of ſoda, a ſmall proportion of carbonate of potaſh, ſulphate of potaſh and ſoda, muriate of ſoda, charcoal, iron in the ſtate of *Pruſſian blue*, as has been obſerved by Henckel, and earth partly free, partly combined with fixed alkali, as in that of Cherbourg. To ſeparate theſe ſubſtances, and obtain the carbonate of ſoda in a pure ſtate, they are formed into a lixivium with cold diſtilled water: this lixivium is filtrated, in order to ſeparate the earth, the iron, and the carbonaceous

carbonaceous matters: laſtly, it is evaporated in the ſame way as potaſh. This alkali is more eaſily purified than potaſh; for as it cryſtallizes ſooner, it ſeparates more readily from the cauſtic ſoda. It however carries with it, when it cryſtallizes, ſome of the neutral ſalts and the Pruſſian blue contained in the lixivium, which can be ſeparated only by repeated ſolution, and ſucceſſive cryſtallization.

3. There are fixed ſalts prepared in pharmacy, which have been ſtrongly recommended by Takenius, and ſtill bear his name. This chemiſt's proceſs conſiſts in putting the plant from which the ſalt is meant to be extracted into an iron pot, and heating that veſſel till its bottom become red-hot: the plant is conſtantly ſtirred, and exhales a good deal of ſmoke: at length it kindles: it muſt now be covered up with a lid, which may ſuffer the ſmoke to eſcape, but extinguiſh the flame. By this means, the plant is gradually conſumed. When reduced to a ſort of blackiſh cinder, it is lixiviated with boiling water; and, on evaporating this lixivium to dryneſs, a yellowiſh or brown ſalt is obtained. This ſalt is often alkaline, but very impure; it contains a good deal of extractive matter, from which it derives a colour, and which is mixed with all the neutral ſalts contained in the plant: it is in a ſort of ſaponaceous ſtate, which makes it very fit for being employed in medicine. But we muſt not imagine that it poſſeſſes all the virtues of the plant from which it was extracted; for the combuſtion neceſſarily alters the principles of the plant. It would be worth while to examine, by a chemical analyſis, the ſeveral fixed ſalts prepared in Takenius's way, in order to diſcover what ſaline and extractive ſubſtances they contain;

contain; and to aſcertain their virtues, and the quantities in which they are to be adminiſtered.

4. When the aſhes of vegetables are deprived, by lixiviation, of all the ſaline matters which they contained, the reſidue is nothing but a pulverulent ſubſtance, more or leſs white or coloured, inſipid, inſoluble in water, and which has been hitherto thought to conſiſt of earths.

The magnet attracts iron from this matter. This iron, as well as the manganeſe which has in like manner been for ſome time obtained from this reſidue of vegetables, muſt have exiſted ready formed in the plant. A number of naturaliſts are of opinion, that plants owe their colours to iron. M. Baumé, who, in his Memoir on clays, mentions the earthy reſidue of vegetables, affirms, that it forms, with the ſulphuric acid, alum and ſulphate of lime, a little different from that which owes its formation to pure calcareous earth. From this M. Baumé concludes, that the earth of vegetables conſiſts of alumine, and of another earth, nearly of a ſimilar nature with calcareous earths; yet diſtinct from theſe, as it does not form quick-lime by the action of fire. He thinks that alumine is formed in theſe ſubſtances by the colliſions to which ſiliceous earth is expoſed in them, and by the action of the acids with which it combines; and that alumine, once formed, paſſes into the ſtate of calcareous earth, in conſequence of undergoing new elaborations in the tubes of vegetables.

We cannot help obſerving in this place, that the diſcoveries made in Sweden concerning the ſaline nature of the bones of animals,—which are to animals preciſely what the fibrous texture of plants is to vegetable bodies,

dies,—ſeem to ſuggeſt, that the reſidue of vegetables is any thing rather than an earth. Perhaps an exact analyſis, ſuch as has not yet been made, might ſhew, that what has been taken for an earthy matter, is rather calcareous phoſphate; at leaſt we may ſuſpect as much from the experiments of Margraff and M. Berthollet, who have obtained phoſphorous from the grains of muſtard, from the gluten, and from various other vegetable matters;—as well as from the experiments of M. Haſſenfratz, who has extracted phoſphoric acid from a great many marſh plants.

CHAP.

CHAP. XXII.

Of Fermentations in general, and of the Spirituous Fermenation in particular.

AFTER conſidering vegetables in the ſtate in which nature preſents them to our obſervation, we may attend to the alterations and changes which they are liable to ſuffer from various circumſtances. Theſe alterations depending entirely on their nature, are always the effect of a phenomenon, called *fermentation.*

Fermentation is a ſpontaneous motion which ariſes in vegetables, and ſometimes produces a total change of their properties. This motion is peculiar to the fluids of organic bodies; and no ſubſtances, but ſuch as have been elaborated by the functions of vegetable or animal life, are ſuſceptible of it. Chemiſts have not inſiſted ſufficiently on this important truth, the application of which to the phænomena of organized ſubſtances is ſingularly uſeful in medicine.

There

There muſt ſeveral circumſtances concur to promote this fermentation. Such as,

1. A certain degree of fluidity. Dry ſubſtances ſuffer no ſort of fermentation.

2. A more moderate or a more intenſe heat. The degrees of heat vary with the ſorts of fermentation; but cold ſtops the progreſs of every kind of fermentation.

Boerhaave, and after him other chemiſts, have diſtinguiſhed fermentation into three kinds: Spirituous fermentation, which produces alcohol;—acetous fermentation, which affords vinegar or acetous acid;—and putrid fermentation or putrefaction, which produces ammoniac. It is to be obſerved, that there are ſeveral fermenting motions, which cannot be referred to any of theſe three claſſes of fermentation.—Such, perhaps, are the fermentations of bread, of inſipid mucilages, of colouring matters, &c. It has been thought, that fermentations always ſucceed each other in the order in which we have mentioned them: but there are bodies which become acid, without paſſing previouſly into the ſtate of putrefaction; and, in other inſtances, putrefaction takes place without being preceded by the two other ſpecies of fermentation.—We may likewiſe obſerve, that the internal motion of maturation ſeems to conſtitute a ſpecies of primary fermentation, which calls forth the ſaccharine matter from a latent ſtate. It is ſpirituous fermentation which affords alcohol. In order to become well-acquainted with the phænomena of this ſpecies of fermentation, we may conſider, 1. The conditions neceſſary to its productions; 2. The phænomena which accompany it; 3. The ſeveral matters ſuſceptible of it;

4. The cauſe of this internal motion; 5. The product which it forms.

It is well known to chemiſts, that all vegetable matters are not ſuſceptible of ſpirituous fermentation, and that, in order to its taking place, ſeveral different circumſtances muſt concur. Theſe we are to conſider as neceſſary conditions of ſpirituous fermentation.

Theſe conditions are,

1. A ſaccharine mucilage. No other matter is ſuſceptible of ſpirituous fermentation.

2. A ſomewhat viſcous fluidity. Too fluid a juice is no more ſuſceptible of ſpirituous fermentation than one that is too thick.

3. The heat of—from ten to fifteen degrees in Reaumur's, or from fifty-five to ſixty-five of Fahrenheit's.

4. A conſiderable maſs of matter in which a rapid motion may be excited.

When theſe four conditions concur, ſpirituous fermentation then takes place; and certain phænomena invariably accompany it. The following are what have been diſcovered by obſervation concerning it.

1. A motion is raiſed in the liquor, which becomes more and more conſiderable, till at length the fermentation is fairly eſtabliſhed through the whole maſs.

2. The bulk of the mixture is conſiderably enlarged, in proportion as the motion is communicated through the whole maſs.

3. The liquor loſes its tranſparency, and is rendered turbid by opaque filaments appearing in motion through all parts of it.

4. There is a heat produced, amounting, according to the Abbé Rozier, to eighteen degrees of Reaumur, or ſeventy-two and one half, Fahrenheit.

5. The ſolid parts intermixed with the liquor are raiſed, and ſwim, in conſequence of the diſengagment of an elaſtic fluid.

6. There is a conſiderable quantity of carbonic acid gas diſengaged. This gas forms a ſtratum above the liquor in the veſſel containing it, which may be eaſily diſtinguiſhed from common air. It was on air thus produced, that Dr Prieſtley and the Duke de Chaulnes made their fine experiments. It extinguiſhes lights, and proves fatal to animals. It produces from lime-water a chalky precipitate: Cauſtic alkali it cauſes to cryſtallize perfectly. This acid is what renders the employment of thoſe who are engaged in conducting fermentation ſo very dangerous to health.

7. The diſengagement of this gas is attended with the formation of a great many bubbles, which depend on the viſcidity of the liquor through which the carbonic acid muſt paſs.

All theſe phænomena ceaſe by degrees, as the liquor loſes its ſweet taſte and ſaccharine nature, and becomes briſk, pungent, and capable of producing intoxication.

Men have been taught by neceſſity to prepare fermented liquors from many different vegetable ſubſtances. But experience has evinced, that none but ſaccharine matters are properly ſuitable for this purpoſe. The ſaccharine matters which are moſt commonly uſed in the preparation of fermented liquors, and which therefore beſt deſerve to be examined here, are the following:

1. The juice of the grape, properly ſo called, produces wine, the beſt of all fermented liquors. In learning the art of cultivating vines, which is of great importance, it will be proper to examine, 1. The nature of the ſoil on which the vine grows; a dry parched ſoil is known to be very favourable to this plant, as it does not thrive well in a ſtrong fat ſoil:—2. The mode of managing and cultivating this vegetable; it is to be pruned, and its branches bent down, to retard the progreſs of the ſap. Care muſt by taken to have the vine expoſed to the ſun, particularly to the reflection of his rays from the ground, &c.; and it does not need to be ſupplied with any ſort of manure, &c.:—3. The hiſtory of the vegetation of the vine, its expoſure, its flowering, and the formation and ripening of the grape:—4. That of the accidents to which it is liable from froſt, rains, moiſture:—5. The ſeaſon of the vintage, which ſhould be dry and hot. When this previous knowledge is acquired, the art of making wine is next to be conſidered; which conſiſts in putting the grapes, after pulling them, into a veſſel expoſed to the heat of fifteen or ſixteen degrees, and cruſhing, ſtirring, and turning them: fermentation is then produced, with all its uſual phænomena. The juice of the grape, or muſt, ſhould not be either too fluid or too thick; when too fluid, it may be thickened by boiling; when too thick, it muſt be diluted with water. When the wine is made, it is drawn off, and put into open caſks. It there ſuffers inſenſibly a ſecond fermentation, by which its principles are more intimately combined. It precipitates a fine lee, and a ſalt known by the name of *tartar*, which we have examined in a former chapter of this volume. To preſerve wine,

rags

rags dipped in ſulphur are burnt in the caſk in which it is contained.

It is farther of importance, to be able to diſtinguiſh the different ſorts of wine. France produces a great variety of excellent wines: thoſe of Burgundy are the beſt for conſtant uſe: their principles are ſo perfectly combined, that none is predominant over the reſt. The vines of the diſtrict of Orleans acquire nearly the ſame qualities with thoſe of Burgundy, when time has mellowed their harſhneſs, and ſubdued the exceſs of ſpirit or alcohol which they contain. The red wines of Champagne are very excellent, and of a delicate flavour. The white wine of the ſame country which does not ſparkle, is much better than that which ſparkles; for the taſte of the latter is tart and ſouriſh; and it owes its quality of ſparkling to its containing carbonic acid, in conſequence of having been bottled before the fermentation had been finiſhed. The wines of Languedoc and Guyenne are deep coloured, and highly tonic and ſtomachic; eſpecially when old. The wines of Anjou are ſtrongly ſpirituous, and therefore ſoon intoxicate. As to foreign wines, thoſe of Germany, known by the name of *Rheniſh* and *Moſelle* wines, are white, very ſpirituous, and of a freſh poignant taſte: They very ſoon intoxicate. Some Italian wines, ſuch as thoſe of Orvietto, Vicenza, and Lachryma Chriſti, &c. are well fermented, and not much inferior to good French wines. Thoſe of Spain and Greece are, in general, ſweet, crude, imperfectly fermented, and very unwholeſome. We muſt, however, except thoſe of Rota and Alicant, which are deſervedly eſteemed very uſeful ſtomachics and cordials.

2. Apples and pears afford cyder and perry: Theſe are pretty good liquors; and M. D'Arcet has ſhown, that brandy may be obtained from them.

3. Cherries afford a pretty good wine, from which that ſpecies of brandy which the Germans call *kirchen-waſſer* is extracted.

4. Apricots, peaches, and plums, afford a ſpecies not quite ſo good.

5. Sugar diſſolved in water eaſily ferments. From this ſort of wine, prepared from the juice of the cane, there is a ſpirit extracted, which is known by the names of *taffia*, *rum*, *guil dive*, &c.

6. Gramineous ſeeds, and of theſe eſpecially barley, afford a ſort of wine, called *beer*. The following are the proceſſes of the art of brewing: The barley is ſteeped in water for thirty or forty hours, to ſoften it. It is then laid in a heap, and left in that ſtate till it begin to germinate. It is then dried in a kiln; and the buds are ſeparated by ſifting: after which, it is coarſely ground into what is called *malt*. The malt is put into a veſſel, called the *maſh-tun*, and hot water poured upon it to diſſolve the mucilage. This being drawn off, a ſecond quantity of hot water is poured upon the malt; and in like manner drawn off. This fluid is called *wort*, and boiled with hops; after which it is put to ferment, with yeaſt, into a veſſel called the *cooler*. When the fermentation begins to ſubſide, the beer is ſtirred, and drawn off into caſks. The ſecond fermentation throws up a ſcum called *yeaſt*, which is kept for fermenting future brewings. Germination calls forth, from a latent ſtate, a certain ſaccharine matter in barley, to which

which malt owes its property of affording a wine. A ſimilar liquor might be prepared from moſt other gramineous ſeeds.

All theſe facts concur to ſhow, that the ſaccharine matter is the only principle of vegetables ſuſceptible of ſpirituous fermentation, and that water is neceſſary to the production of this inteſtine motion. Modern chemiſts are of opinion, that vinous fermentation conſiſts ſolely in a change of the proportion of the ſaccharine principles. A great part of the oxigene combines with the carbonaceous matter, to form the carbonic acid that is diſengaged during the fermentation; whilſt the hydrogene, combined with a ſmall portion of carbone, forms a very light and ſubtle combuſtible body, which contains much leſs carbonaceous matter than ſugar, and is much lighter, and much more inflammable, and conſtitutes what is called *alcohol*.

The product of all theſe fermented ſubſtances is a peculiar liquor, more or leſs coloured, of an aromatic ſmell, of an hot, poignant taſte; which, when taken in a ſmall quantity, re-invigorates the fibres, and, when drunk in too great abundance, intoxicates; and is known over all the world by the name of *Wine*.

The wine of grapes, for inſtance, is a compound conſiſting of a large proportion of water,—an aroma, peculiar to each different ſort of wine,—alcohol,—an eſſential ſalt, called *tartar*,—and an extracto-reſinous colouring matter, to which red wines owe their colour.

Before proceeding to explain the means by which theſe principles may be ſeparated, it may be proper to give

ſome account of the properties and uſes of pure unaltered wine. Wine, by means of the water, alcohol, and eſſential acid ſalt which it contains, is capable of diſſolving a great many bodies. It unites with extracts, reſins, certain metals, &c. Theſe are the properties which render wine fit for entering into medical preparations. Theſe preparations are, 1. Emetic wine, which is prepared by macerating four ounces of *crocus metallorum* in two pounds of good white wine. The liquor is filtrated, or elſe made uſe of in a turbid ſtate, as a powerful ſtimulus in caſes of apoplexy, palſy, &c.—2. Chalybeate wine, prepared by digeſting an ounce of iron-filings with two pounds of white wine. It is an excellent tonic and aperient.—3. Vegetable wines, which are prepared, A, either with red wine, in which aſtringent aromatic plants are macerated; or, B, with Spaniſh wine. Both the wine of ſquills, and the liquid laudanum of Sydenham, are prepared with this ſpecies of wine. The latter of theſe is prepared by digeſting, for a number of days, two ounces of opium cut into ſlices, an ounce of ſaffron, and a drachm of cinnamon and cloves, in a pound of Spaniſh wine. This mixture, taken in dozes of a few drops, is an excellent calming medicine, eſpecially when there is reaſon to fear that opium might weaken the patient too much, or might hinder ſome uſeful evacuation.

The action of fire is commonly uſed to decompoſe wine, and ſeparate its different principles. The liquor is diſtilled in an alembic of copper plated with tin, with a receiver adapted to it. As ſoon as the wine is heated to ebullition, it affords a white fluid, in a ſmall degree opaque and milky, of a hot poignant taſte, and of

a ſtrong ſweet ſmell. This fluid is collected into the receiver, till ſuch time as the vapours exhaling ceaſe to be ſuſceptible of inflammation at the approach of a candle. This product is what is called *Brandy:* It is a compound of water, alcohol, and a ſmall quantity of oil, which obſcures its tranſparency while it is diſtilled, and afterwards communicates to it a yellow colour. The colour of old brandy is not, however, owing ſolely to this oil which paſſes with it when it is diſtilled, but rather to the extractive matter of that part of the wood of the caſks which it has diſſolved. Alcohol, as we ſhall hereafter ſee, is extracted from brandy. Wine, after affording brandy, aſſumes a deeper colour, and a harſh acid taſte; it is alſo turbid, and may be obſerved to contain a great many ſaline cryſtals, which are nothing but tartar. This fluid is now, therefore, totally decompoſed, and its original properties cannot be again communicated to it, by combining the ſpirituous product with the reſidue: The analyſis is therefore complicated. The reſidue of wine from which brandy has been extracted, takes, by evaporation, the form and conſiſtency of an extract. The colouring part may be ſeparated by alcohol, which does not affect the tartar. This tincture is not liable to be precipitated by water. When evaporated to dryneſs, the reſidue readily takes fire, and is ſoluble in water. It is, in its nature, a true reſino-extractive ſubſtance, which the alcohol formed by the fermentation has taken up from the pellicles of the grapes. From this analyſis it appears, that wine is actually compoſed of water, alcohol, tartar, a colouring matter, and an aroma, which is deſtroyed or modified by the action of fire. We already know the nature and properties

of moſt of theſe ſubſtances: we have only alcohol to examine.

Before we proceed to ſpeak of this product, it will be proper to ſay ſomething concerning a ſubſtance which is precipitated from wine while it ferments, and is called *lees*. It conſiſts of the ſeeds and ſkins of grapes, impure tartar, and ſulphate of potaſh, or vitriolated tartar. Brandy is obtained from it by diſtillation with naked fire. When treated in a retort, it affords an acid phlegm, and ammoniac; and its coaly reſidue contains carbonate and ſulphate of potaſh. The lees of wine, incinerated in the open air, afford cauſtic potaſh, mixed with carbonate and ſulphate of potaſh; a ſubſtance known in the arts by the name of *cendres gravelees*. The particulars which we are to relate concerning the properties of alcohol, will complete what has been here ſaid concerning the properties of lees.

Several chemiſts were of opinion, that the alcohol, in this analyſis of wine, was only diſengaged by the action of the fire. But if this ſubſtance were ready formed in the wine, it would be obtained by a very gentle heat, whilſt this can be effected only by ebullition. Thus, modern chemiſts conceive, that the alcohol is formed by the heat of ebullition, that its principles, *viz.* a large proportion of hydrogene, with a ſmall quantity of carbone, combine together during the diſtillation of wine; in ſhort, that this liquor contains only the principles of alcohol.

CHAP.

CHAP. XXIII.

Of Alcohol, or the Product of Spirituous Fermentation.

BRANDY, obtained from wine by diſtillation with naked fire, is a compound of alcohol, water, and a ſmall portion of oily matter. Diſtillation is employed to ſeparate theſe ſubſtances, and give the alcohol pure. There are ſeveral proceſſes for the diſtillation of alcohol. M. Baumé recommends the diſtillation of brandy on a balneum-mariæ, to be repeated as often as may be neceſſary for the extraction of all the ſpirit which it contains. He directs, to ſeparate the firſt fourth part of the product of the firſt diſtillation, and, in like manner, the firſt half of the product of the ſucceeding diſtillations; then to mix all theſe firſt products together, and rectify them by a gentle heat. The firſt half of the liquor which paſſes in this rectification, is the pureſt and ſtrongeſt alcohol: the reſt is a weaker alcohol, but ſtill better for ordinary purpoſes. Rouelle directs to extract, by diſtillation on the water-bath, one half of the brandy made uſe of: this firſt product is common alcohol. By rectifying

fying it twice, and reducing it about two thirds of its original quantity, the ſtrongeſt alcohol is obtained: This, according to Kunckel's proceſs, is to be again diſtilled with water, to ſeparate the oil by which it is altered. This alcohol, after the diſtillation with water, is rectified; and the operator is now certain of its being perfectly pure. The reſidue of diſtilled brandy is nothing but water impregnated with ſome particles of colouring matter, with a peculiar oil floating on its ſurface.

It may be naturally inferred, that this fluid being prepared by various proceſſes, will be, at different times, of different degrees of ſtrength. Attempts have long been made to diſcover ſome means of aſcertaining its purity. It was at firſt thought, that the alcohol which burns readily, and leaves no reſidue, muſt be very pure: But it is now known, that the heat produced by its combuſtion is ſufficiently ſtrong to diſſipate all the phlegm which it may contain. Powder has been propoſed as a teſt of its purity. Alcohol that does not kindle gunpowder, when it is itſelf kindled, and applied to it in a ſpoon, is conſidered as bad; but if it does kindle the powder, it is thought very good. This proof, however, is fallacious; for when any conſiderable quantity, even of the beſt alcohol, is poured on a little powder, the water which it affords as it burns, moiſtens the powder ſo as to hinder it from kindling; whereas, again, the ſame powder may be kindled, by burning at its ſurface a very ſmall quantity even of phlegmatic alcohol. This method of proof is therefore not more certain than the former. Boerhaave gives a very good proceſs for aſcertaining the purity of alcohol. It conſiſts in caſting dry powdered

potaſh

potaſh into the alkali under examination. The potaſh enters into union with the ſuperabundant water of the alcohol, and forms with it a more ponderous and a higher coloured fluid, which does not mix with the alcohol, but ſinks under it. Laſtly, M. Baumé, proceeding upon this principle, that the purer alcohol is, ſo much the more does its levity exceed that of water, has contrived an areometer, by means of which the degree of the purity of this, or of any other ſpirituous liquor, may be accurately aſcertained. When that inſtrument is immerſed in alcohol, the purer the fluid is, ſo much the deeper does it ſink. He has aſcertained, by a number of accurate experiments, that the pureſt and moſt highly rectified alcohol gives thirty-nine degrees of his areometer, at ten degrees of Reaumur's thermometer. The method of conſtructing this inſtrument, with the reſults which alcohol afforded when mixed with various quantities of water, may be ſeen in his Elements of Pharmacy, and may be applied to determine the ſtrength of ſpirit of wine by the hydrometer.

Pure alcohol, obtained by the proceſs above deſcribed, is a tranſparent fluid, very moveable, and very light, which weighs ſix drachms and forty-eight grains, in a bottle containing an ounce of diſtilled water. Its ſmell is poignant and agreeable; its taſte hot and pungent. It is exceedingly volatile. When expoſed even to a ſlight degree of heat in cloſe veſſels, it aſcends, and paſſes unaltered into the receiver. By this means it is concentrated; and any little water which it might contain is ſeparated from it. On this account the firſt portions are the ſweeteſt, the pureſt, and the moſt volatile. It was formerly thought, that there was a good deal of air diſ-

engaged

engaged from alcohol when diſtilled; but what was thought to be air is now known to be the ſpirituous part of the fluid, which eſcapes from the water, and is volatilized in the ſtate of gas.

When alcohol is heated in contact with air, it ſoon kindles, and burns with a light flame, the middle of which is white, and the edges blue: if it has been well dephlegmated, it burns in this manner without leaving any reſidue. Various chemiſts have attempted to diſcover what products alcohol afforded when burnt. They have aſcertained, that its flame is not accompanied with any ſoot or ſmoke, and that the products volatilized prove to be nothing but pure water, inſipid, inodorous, and perfectly in the ſame ſtate with diſtilled water. This phænomenon induced Boerhaave to think, that the flame was owing to the water; and his opinion receives confirmation from what is at preſent known concerning the hydrogenous gas obtained from the decompoſition of water,—and concerning the compoſition of water by the combuſtion of the ſame gas with vital air. M. Lavoiſier, on burning alcohol in a chimney, which was ſo conſtructed and diſpoſed as to collect the vapours, diſcovered, that the quantity of water obtained is greater than the quantity of alcohol burnt; a fact from which it appears, that alcohol contains a great deal of hydrogenous gas. On the other hand, M. Berthollet has remarked, that when a mixture of alcohol and water is burnt, the fluid reſidue precipitates lime-water. This experiment ſhews, that alcohol contains a little carbonaceous matter, which, by its combuſtion, or combination with oxigene, forms carbonic acid. Chemiſts have entertained different opinions concerning its nature. Stahl,

Boerhaave,

"Boerhaave, and ſeveral others, have conſidered this fluid as a compound of a very ſubtle oil, with an attenuated acid and water. According to this opinion, therefore, it is a ſort of acid ſoap. Others, at the head of whom Cartheuſer and Macquer deſerve to be named, think alcohol to conſiſt of phlogiſton and water. The true nature of this liquor is not well known; but it is rather conſidered as a particular compound, conſiſting of a large proportion of hydrogene, with a ſmall quantity of carbone.

Alcohol, when expoſed to the air, is evaporated at the temperature of ten degrees above the freezing point, and leaves no reſidue, except a little water, when it has not been ſufficiently dephlegmated. The hotter the atmoſphere, ſo much the more rapid is the evaporation. It is attended with a greater or a leſs degree of cold, according to its rapidity. At 68 degrees of heat above o in Reaumur's thermometer, 185° Fahrenheit, alcohol takes the form of an elaſtic fluid.

Alcohol combines with water in any proportion, and is perfectly ſoluble in it. This ſolution is attended with heat, and forms different ſorts of brandy, the ſtrength of which is in proportion to the quantity of the alcohol. So ſtrong is the affinity of combination between theſe two fluids, that water is capable of ſeparating from alcohol many of the other bodies which may be united with it; and again, alcohol decompoſes moſt ſaline ſolutions, and precipitates the ſalts. On account of its poſſeſſing this property, Boulduc has propoſed the uſe of alcohol to precipitate the ſalts contained in mineral waters, and obtain them without alteration.

Alcohol

Alcohol does not act on pure earths. We know not whether it be liable to be altered by barytes or magnesia. Lime appears to be capable of producing some change upon it; for when alcohol is distilled on this salino-terreous substance, the fluid acquires a peculiar smell. But this phænomenon has not been sufficiently attended to.

The fixed alkalis actually decompose alcohol, as is proved by the preparation known in pharmacy by the name of *acrid tincture of tartar*. In preparing this medicine, a quantity of potash is melted in a crucible, and either pulverized hot, or put into a matrass: highly dephlegmated alcohol is poured to three or four fingers depth above the salt: the matrass is closed with another of a smaller size: these are luted together, and the whole is digested on a sand-bath, till the alcohol acquire a reddish colour. Either more or less alkali remains at the bottom of the vessel. By distilling the acrid tincture of tartar, we obtain an alcohol of a sweet smell, but little altered; and there remains in the retort a matter resembling a saponaceous extract, which, when distilled by naked fire, affords alcohol, ammoniac, and a light empyreumatic oil. After this operation, a little charcoal remains, which is found to contain the potash. From this experiment it would appear, that alcohol contains or forms an oil, which the fixed alkali seizes, and forms with it a real soap that is found in the portion of the alcohol which has not suffered decomposition. The *lilium of Paracelsus* differs from the acrid tincture of tartar, only in that the fixed alkali employed in the preparation of it appears to have been reduced to a caustic state by the metallic oxides with which it was heated.

The

The *martial*, *jovial*, and *cupreous* reguli of antimony, of each four ounces, are fuſed together, reduced to powder, and detonized with eighteen ounces of nitre, and as much tartar: they are urged with fire till they melt; the mixture is then pulveriſed, put into a matraſs, and highly dephlegmated alcohol poured upon it, to the depth of three or four fingers breadth above the powder. This mixture, digeſted on a ſand-bath, aſſumes a beautiful red colour, deeper than that of the acrid tincture of tartar, and exhibits all the ſame phænomena. That tincture may be rendered entirely ſimilar to the lilium of Paracelſus, by digeſting alcohol on cauſtic fixed alkali, inſtead of uſing fixed ſalt of tartar, which is not entirely deprived of its carbonic acid by the action of fire, unleſs it be kept for a long time red-hot. M. Berthollet is convinced that theſe tinctures are nothing but ſolutions of cauſtic potaſh in alcohol, and they afford an happy mode of obtaining this alkali very pure, as they leave it ſeparate by evaporation. Alcohol acts in the ſame way on pure ſoda. The acrid tincture of tartar, and the lilium, are very good tonics, and powerful diſcuſſives. They are employed in all caſes in which the natural ſtrength of the patient is not ſufficient to ſupport the progreſs of his diſeaſe to a criſis, as in the malignant fever, ſmall-pox of a bad kind, &c.

The action of cauſtic ammoniac on alcohol has not yet been examined.

All the acids exhibit with alcohol phænomena highly worthy of obſervation. When a quantity of ſtrongly concentrated ſulphuric acid is poured on an equal quantity of rectified alcohol, a remarkable heat and hiſſing take place. The two ſubſtances become coloured; and

there is at the ſame time exhaled from them a ſweet ſmell, reſembling that of lemons, or the apple called the *golden rennet.* If the retort in which this mixture is uſually made be placed on a hot ſand-bath, with two large balloons adapted to it, the firſt being immerſed in a veſſel full of cold water, the products obtained are, 1. A ſweet-ſmelling alcohol. 2. A liquor called æther, of a very ſweet ſmell, extremely volatile, and whoſe preſence is indicated by the ebullition of the liquor contained in the retort, and by the large ſtriæ with which the ſides of the veſſel are furrowed. Care muſt be taken to cool the receiver with wet cloths. 3. After the æther follows ſulphureous acid, the white colour and ſmell of which ſhew that it is time to change the receiver, in order to obtain the æther ſeparate. 4. There is at the ſame time volatilized a light yellowiſh oil, which is called *ſweet oil of wine.* The fire muſt be greatly moderated after the æther has paſſed; becauſe the matter now remaining in the retort is black and thick, and ſwells conſiderably. 5. When the ſweet oil is all diſtilled, there likewiſe paſſes ſulphureous acid, which becomes gradually thicker, till at laſt it is nothing but black and dirty ſulphuric acid. 6. Continuing this operation by a moderate fire, the reſidue is at length ſo much dried as to take the form and conſiſtency of a bitumen. This bitumen expoſed to a very ſtrong fire, affords an acid liquor, and a dry yellowiſh ſubſtance like ſulphur. M. Baumé, who has made a long train of experiments on ſulphuric æther, has examined this reſidue with a great deal of care: He has found in it ſulphate of iron, Pruſſian blue, a ſaline ſubſtance, and a peculiar earth, the nature of which he has not determined.

mined. He even aſſerts, that the yellow ſublimate which it affords is not ſulphur; and that it remains white and pulverulent, without being kindled on the coals. To theſe particulars we ſhall add, that a new quantity of æther may be obtained from the reſidue from which æther has been once obtained, by adding to it, according to M. Cadet's proceſs, one third part of alcohol dephlegmated by potaſh, and diſtilling that mixture. Theſe diſtillations may be ſeveral times repeated; ſo that from a mixture of ſix pounds of ſulphuric acid with alcohol, by adding to it ſucceſſively fifteen pounds of the latter of theſe fluids, more than ten pounds of good æther may be obtained.

The operation which we have been deſcribing is, by the phænomena which it preſents, one of the moſt ſingular, and at the ſame time one of the moſt important, in all chemiſtry, as it affords ſome information concerning the principles of which alcohol is compoſed. There are two opinions concerning the formation of æther; of which it is proper for us to give ſome account. Macquer, who, as has been mentioned, thinks alcohol a compound of water with phlogiſton, is of opinion, that in the formation of æther, the ſulphuric acid, ſeizing the water of the alcohol, brings it nearer in nature to oils. Thus, according to this opinion, there paſſes, at the firſt, alcohol a little altered;—then a fluid of a middle character between alcohol and oil, which is æther;—and, laſtly, a genuine oil; becauſe the ſtronger the heat employed to obtain the æther, with the greater energy does the ſulphuric acid act on the principles of the alcohol. Bucquet, ſtruck with a ſtrong objection which he made to this theory, namely, its being hard to

conceive how the ſulphuric acid, impregnated as it muſt be, from the time when it begins to act upon the alcohol, with a certain quantity of water, abſtracted from that fluid, can, notwithſtanding this dilution, re-act with ſuch force on another part of the ſame alcohol, as to reduce it into an oily ſtate,—has advanced another opinion concerning the production of æther. He conſidered alcohol as a fluid compounded of oil, an acid, and water: He thought, that when the ſulphuric acid was mixed with alcohol, the reſult of the mixture was a ſort of bituminous fluid, which afforded by heat the ſame principles with all the other bitumens,—that is to ſay, a light oil, very odorous, and highly combuſtible; a ſort of naphtha, which was æther; and then an oil, leſs volatile, but higher coloured than the former, which is the ſweet oil of wine. We will in fact ſee, in examining the properties of æther, that this fluid has all the characteriſtics of a very ſubtle oil, ſuch as naphtha. This theory does not afford a ſufficiently clear explanation of what paſſes in the preparation of æther. It appears, that the alcohol deprives the ſulphuric acid of its oxigene;—that a part of the hydrogenous principle contained in the alcohol, combines with this oxigene to form water;—and that the alcohol, after loſing that part of its hydrogene, forms æther. But we are not acquainted with all that paſſes in this operation.

Æther, obtained by the proceſs here deſcribed, is not very pure: It is combined with alcohol and ſulphureous acid. To rectify it, it is diſtilled in a retort, on a ſand-bath, with fixed alkali. This ſalt combines with the ſulphureous acid, and the æther then paſſes very pure by the moſt moderate heat. By ſeparating the firſt half

of

of this product, the æther is obtained in the pureſt and moſt highly rectified ſtate.

Æther is a fluid lighter than alcohol, of a ſtrong ſweet ſmell, ſuſceptible of great expanſion, and of a hot and pungent taſte. It is ſo volatile, that when ſtirred or ſhaken, it is diſſipated in an inſtant. When evaporating, it produces a cold ſufficient to freeze water, as M. Baumé has ſhewn by his beautiful experiments. It is reduced into a ſort of æthereal gas, which burns with rapidity. Air in which æther is contained, in a ſtate of ſolution, will paſs through water without loſing its odour or inflammability. Æther is very eaſily kindled, by being heated in the open air, or brought into contact with a burning body; the electric ſpark likewiſe kindles it. It diſplays a very luminous white flame, and leaves a black, and ſeemingly carbonaceous, mark on the ſurfaces of bodies expoſed to its flame. M. Lavoiſier has proved, that carbonic acid is formed during the combuſtion of this liquor; and M. Scheele, that the reſidue of æther burnt on a little water contains ſulphuric acid.

Æther, according to the Count de Lauraguais, is diſſolved in ten parts of water. The phænomena which æther is capable of exhibiting with ſaline ſubſtances, have not yet been particularly examined. We know only how it re-acts on acids. Lime and the fixed alkalis do not appear capable of producing any alteration upon it. Cauſtic ammoniac mixes with it in all proportions, forming with it a matter, the mixed ſmell of which might produce very happy effects in ſpaſmodic complaints. The ſulphuric acid becomes conſiderably hot with æther, and is capable of converting a great part of it into ſweet oil of wine, by diſtillation. The fuming ni-

trous acid excites a conſiderable efferveſcence in æther; and æther appears to become higher coloured, and more oily, and to acquire greater conſiſtency, in conſequence of the admixture of this acid. When mixed with the muriatic ſolution of gold, æther retains a part of the metal, acting, it would appear, in the ſame way as volatile oils, which alſo retain a part of the oxide of gold. It diſſolves volatile oils and reſins, like alcohol: And phyſicians often make uſe of æthereal tinctures.

Æther is thought a powerful tonic, and a very good antiſpaſmodic medicine. It is adminiſtered in hyſteric complaints, and in ſpaſmodic colics. It acts very ſpeedily in promoting digeſtion, when this is retarded by a weakneſs of the ſtomach. It muſt, however, be adminiſtered with prudence, for it is known to be dangerous when taken in too great quantities. It is alſo applied externally, with very happy effects, to remove the headach, and cure burnings, &c. Hoffman, who paid much attention to the combinations of alcohol with the ſulphuric acid, made uſe of a medicine conſiſting of ſweet oil of wine, diſſolved in alcohol, which he called his *anodyne mineral liquor*. The Faculty of Medicine of Paris have added æther to this liquor, and have, in their Diſpenſary, directed it to be prepared by mixing two ounces of alcohol, which paſſes before the æther, two ounces of æther, and twelve drops of ſweet oil of wine. This medicine is employed in the ſame way as æther, but is greatly inferior in its effects.

The nitric acid acts upon alcohol with great rapidity. Navier of Chalons is the firſt who has given an eaſy and not very expenſive proceſs for the preparation of nitric æther. His proceſs is as follows:—Into a very

ſtrong

ſtrong bottle of the manufactory of Séves, pour twelve ounces of very pure and highly rectified alcohol, and immerſe it in cold water, or rather in pounded ice: at ſeveral different times, ſtirring the mixture each time, add eight ounces of concentrated nitric acid: then cloſe up the bottle with a good cork, covered with leather. Set this mixture aſide, in ſome private place, to avoid accidents from the burſting of the bottle,—which ſometimes happens. In a few hours, bubbles ariſe from the bottom of the bottle, are collected in drops on the ſurface of the liquor, and form, by degrees, a ſtratum of genuine æther. This phænomenon continues to go on for four, or from four to ſix days. As ſoon as the motion of the liquor appears to have ceaſed, the cork muſt be pierced with a pin, in order to the emiſſion of a certain quantity of gas, which would otherwiſe force its way out by uncorking the bottle, and carry with it all the æther. When this gas is diſcharged, the bottle may be unſtopped, the liquor contained in it poured into a funnel, ſtopping the under end of the funnel with the finger, and the ſupernatant æther ſeparated from the reſidue, and received into a glaſs phial.

Mr Woulfe has given a different proceſs for the preparation of nitrous æther. He uſes very large veſſels, which afford room for the reception of the air that is diſengaged. Taking a balloon of clear glaſs, ſufficiently capacious to hold eight or ten pints, and terminating in a neck ſeven or eight feet long, he places it on a tripod, high enough to receive under it a chafing-diſh. The neck of the matraſs is to be adjuſted to a tubulated capital, with a glaſs tube ſeven or eight feet long, adapted to its beak. The lower extremity of the tube is received

into a balloon with two necks, the lower part of which is drawn out into a tube, and inſerted into a bottle. The other neck of this balloon joins the bottles compoſing Woulfe's apparatus, which we have already repeatedly deſcribed. When all theſe veſſels are ſufficiently luted together, a pound of rectified alcohol, and as much fuming nitrous acid, is to be poured into the matraſs, through the hole perforated in the capital: this hole muſt then be ſtopped with a cryſtal ſtopper, wrapped in a piece of leather. The mixture becomes immediately exceedingly hot: vapours are diſengaged, and paſs rapidly along the neck of the balloon; and this veſſel being expoſed to a heat ſufficient to boil the liquor which it contains, a quantity of nitric æther paſſes into the balloon employed as a receiver. This proceſs, though very ingenious, is attended with ſeveral inconvenient circumſtances: It takes a long time to ſet up the apparatus which is both very expenſive and very troubleſome: and it ſtill expoſes the operator to danger; for notwithſtanding the room afforded in the veſſels for the reception of the vapours, yet, ſo rapidly are they diſengaged, that the veſſels happen to be pretty often burſt, with conſiderable noiſe.

M. Bogues, in the year 1773, publiſhed another proceſs for preparing nitric æther. He directs to mix, in a glaſs retort, capable of containing eight pints, a pound of alcohol with a pound of nitric acid, weakened ſo as to exhibit only twenty-four degrees of M. Baumé's hydrometer;—to adapt to the retort a balloon of the capacity of twelve pints;—to afford a paſſage to the air, by inſerting, at the juncture of the lute, the barrels of two quills;—and to diſtil the mixture by a very moderate

rate heat, taking care that the retort ſink but a little way in the ſand-bath. By this means he obtained ſix ounces of nitric æther, of ſufficient purity. It appears, from what the Abbé Rozier has ſaid, that Mitouard followed, ſince the year 1770, a proceſs nearly ſimilar to that communicated to the public by M. Bogues. That chemiſt ſubjected four ounces of fuming ſpirit of nitre, with twelve ounces of alcohol, to diſtillation in a retort: He placed the retort gently on the ſand-bath; and by this means, which appeared to him ſimpler than any other that had been recommended, he obtained a quantity of nitric æther, of the ſame kind with M. Navier's. Laſtly, M. de la Planche, apothecary at Paris, has contrived two different ways of preparing nitric æther, each of which has its conveniences. The firſt conſiſts in putting nitre into a tubulated ſtone retort, with a large balloon, and pouring in by the aperture, firſt, concentrated ſulphuric acid, and afterwards alcohol. The ſulphuric acid diſengages ſpirit of nitre, which re-acts upon the alcohol, and forms, almoſt inſtantaneouſly, nitric æther. As æther prepared in this way might be ſuſpected to be partly ſulphuric, he afterwards adopted, in preference to this method, a new proceſs; which is indeed exceedingly ingenious: To a tubulated glaſs-retort, into which he had put ſix pounds of dry nitre, he joined an adapter, and a receiver, communicating by a curved tube with an empty bottle. The bottle, again, by means of a ſyphon, communicated with another bottle, containing three pounds of the beſt alcohol. Then, after properly luting the whole of this apparatus, and placing the retort on a cinder-bath, he poured upon the nitre, through the aperture in the retort, three pounds of concentrated

ſulphuric acid,—ſhut up the retort with a cryſtal ſtopper, urged it with fire, till it was raiſed to ebullition,—and maintained it in that ſtate, till it ceaſed to emit vapours. On this occaſion, the ſulphuric acid diſengages the acid of nitre, one part of which paſſes into the receiver, and the reſt into the ſecond flaſk. At the end of the operation, the receiver contains fuming nitrous acid, the retort ſulphate of potaſh, and the ſecond bottle an æthereal liquor. This æthereal liquor is next diſtilled in a retort, with a ſingle balloon, and only two thirds of the product taken up. This product is diſtilled with a fifth part of fuming nitrous acid, gradually poured upon it, through a long glaſs funnel: of this likewiſe no more than two thirds are diſtilled off. Laſtly, This ſecond product is rectified on potaſh; four ounces are, at the firſt, taken off; and then the remaining three fourths. The four ounces are very pure nitric æther; and the remaining three fourths a nitrous, anodyne mineral liquor. The reſidues of theſe two rectifications are dulciſied ſpirit of nitre.

The nitric æther obtained by theſe proceſſes is a yellowiſh fluid, equally volatile and ſuſceptible of evaporation with ſulphuric æther. Its ſmell is nearly the ſame with that of ſulphuric æther, but rather ſtronger, and not ſo pleaſant. Its taſte is hot, and more diſagreeable than that of ſulphuric æther. It contains a ſmall quantity of ſuperabundant acid. It cauſes the corks to ſtart from the phials in which it is incloſed; a large quantity of gas being conſtantly diſengaged from it. It burns with a brighter flame, and a thicker ſmoke, than ſulphuric æther, and does not leave juſt ſo large a proportion of carbonaceous reſidue. Laſtly, like ſulphuric æther, it

takes

takes up gold from a ſolution of that metal, and becomes charged with a certain quantity of it.

The reſidue of nitric æther is of a lemon-yellow colour; its ſmell is acid and aromatic; its taſte pungent, like that of diſtilled vinegar. According to M. Baumé, it affords, by diſtillation, a clear liquor, the ſmell of which is ſweeter than that of nitric æther, and its taſte an agreeable acid. It reddens ſyrup of violets, combines with water in any proportion, and effervesces with carbonate of potaſh. There remains in the retort, after this liquor is diſtilled off, an amber-yellow matter, friable, and ſimilar in its appearance to real amber, which attracts moiſture from the atmoſphere, becomes pitchy while it continues expoſed to it, and diſſolves in water without rendering it mucilaginous. This ſubſtance, which M. Baumé calls gummi-ſaponaceous, affords in the retort a few drops of an acidulated liquor, which is very clear, of an oily conſiſtency, and a light empyreumatic ſmell. After the diſtillation, there remains a ſpongy coal, which is brilliant, inſipid, and very obſtinately fixed in the fire. Bucquet ſays, that the liquor which remains after the formation of nitric æther, takes, by evaporation, a mucilaginous conſiſtency; and that, in a longer or a ſhorter ſpace of time, there are ſaline cryſtals formed in it, which bear a conſiderable reſemblance to hairy caterpillars, and are called *cryſtals of Hiærne*, from the name of the chemiſt who gave the firſt deſcription of them. This reſidue has been diſcovered to be oxalic acid; and the radical principle of that acid appears therefore to be contained in alcohol.

The muriatic acid does not act in any perceptible manner on alcohol. This acid is only dulcified by ſimple mixture

mixture with this liquor, as are alſo the two others, when mixed in a ſmall proportion with alcohol. M. Baumé, in his Diſſertation on æther, mentions his having obtained a little muriatic æther, by bringing vapours of muriatic acid into contact with vapours of alcohol.—Ludolf and Pott, employed ſublimated muriate of antimony with this view. Baron Bornes directs to diſſolve oxide of zinc in muriatic acid, and to diſtil that ſalt, after concentrating it by evaporation in cloſe veſſels with alcohol. This is an eaſy enough way of obtaining muriatic æther. But no body has paid ſo much attention to this object as the Marquis of Courtanvaux. His proceſs is, to pour into a glaſs-retort a pint of alcohol, with two pounds and a half of muriate of tin, or *fuming liquor of Libavius*. A very ſtrong heat is thus excited; and there ariſes a white ſuffocating vapour, which diſappears when the mixture is ſtirred. An agreeable ſmell then exhales from it, and the liquor takes a lemon-colour. Place the retort on a hot ſand-bath: join to it with luting two balloons; and let the moſt diſtant of the two be immerſed in cold water. The firſt product which paſſes is dephlegmated alcohol; after it the æther aſcends. The aſcent of the æther may be diſtinguiſhed by its ſweet ſmell, and the ſtriæ which it forms on the ſides of the retort. When the ſmell changes, and becomes ſtrong and ſuffocating, the receiver muſt be changed, but the diſtillation ſtill carried on. The product now obtained is firſt a clear acid liquor, with ſome drops of mild oil ſwimming on its ſurface; next, a yellow matter, of the conſiſtency of butter, which is a true muriate of tin; and laſtly, a brown ponderous liquor, which exhales a conſiderable quantity of white vapours.—There

remains

remains in the retort a grey pulverulent matter, an oxide of tin. The æthereal product muſt now be poured into a retort upon a quantity of potaſh: The phænomena which follow are, a lively efferveſcence, and a copious precipitation, both owing to the tin which the acid has carried up with it when diſtilled. By adding a little water, and diſtilling the contents of the retort by a moderate heat, a product is obtained, equal to about one half of the former æthereal product. All the liquors which paſs after the muriatic æther are ſtrongly impregnated with oxide of tin: They attract moiſture from the atmoſphere, and combine with water, without affording any precipitate. It was not known to what cauſe the rapidity with which the muriatic acid contained in the fuming liquor acts upon alcohol, while the pure acid does not act upon it at all, ſhould be aſcribed: but from a diſcovery of Scheele's, it appears that it is owing to the acid being then in the ſtate of oxigenated muriatic acid, in conſequence of which the exceſs of oxigene which it contains converts the alcohol into æther. This theory was firſt advanced by myſelf, in the year 1781; and has been ſince confirmed by the experiments of Meſſrs Berthollet and Pelletier.

M. de la Planche, apothecary, has propoſed the preparing of muriatic æther, by pouring into a tubulated retort ſulphuric acid and alcohol upon decrepitated muriate of ſoda. The muriatic acid gas, diſengaged by the ſulphuric acid, upon entering the receiver, comes into contact with the alcohol in a vaporous ſtate, and combines with it. The reſult of the combination is, an æthereal acid, which, by rectification on fixed potaſh, becomes pure æther. It appears, that in this proceſs the muriatic

muriatic acid deprives the ſulphuric acid of a part of its oxigene.

Muriatic æther is highly tranſparent and volatile. It has nearly the ſame ſmell with ſulphuric æther. It burns in the ſame way, and affords a ſimilar ſmoke. It differs from it, however, in two properties: Muriatic æther exhales, as it burns, an odour equally pungent and lively with that of the ſulphureous acid; and it has a ſtiptic taſte, like alum. Theſe two phænomena indicate this æther to be of a different nature, and poſſibly leſs perfect than the two preceding ſorts of æther. No doubt, when its properties are more minutely examined, it may be found diſtinguiſhed by other more remarkable peculiarities.

After this account of the manner in which theſe three mineral acids act upon alcohol, we are to proceed with the hiſtory of this fluid. Little attention has been paid to the action of the other acids on alcohol. We know only, that it combines readily with the boracic acid; that in conſequence of combination with this acid, it burns with a green flame; and that alcohol abſorbs a quantity of carbonic acid gas, more than equal to its own bulk. As to the neutral ſalts, Macquer has aſcertained, that this ſpirit diſſolves ſulphuric neutral ſalts, but with great difficulty; that nitric and muriatic ſalts combine with it much more readily; and that the leſs intimately the acid is combined with the other principle of theſe ſubſtances, the more of them does the ſpirit uſually diſſolve. Alcohol, boiled on ſulphate of potaſh and ſoda, diſſolved none of either of theſe neutral ſalts. Neither does carbonate of potaſh, or of ſoda, unite with it: Moſt ammoniacal ſalts combine with it.

Deliqueſcent

Deliqueſcent earthy ſalts, ſuch as calcareous and magneſian nitrate and muriate, diſſolve very readily in it. Some metallic ſalts are alſo very ſoluble in alcohol; ſuch as, ſulphate of iron in mother-water, nitrate of copper muriate of iron and of copper, oxigenated muriate of mercury, or corroſive ſublimate. All cupreous ſalts cauſe alcohol to burn with a beautiful green flame. M. de Morveau has ſince given a fuller table of the different degrees in which ſalts are ſoluble by alcohol, which is inſerted in the *Journal de Phyſique.*

Alcohol does not diſſolve ſulphur, either in maſſes or in a powder; but theſe two bodies unite, if brought into contact when they are both in a vaporous ſtate, as has been diſcovered by the Count de Lauraguais. His proceſs conſiſts in putting ſulphur in powder into a glaſs-cucurbite, putting into the ſame veſſel, above the flowers of ſulphur, a bottle filled with alcohol, and heating the cucurbite on a ſand-bath, with a capital and a receiver adapted to it. Both the ſulphur and the alcohol are volatilized at the ſame time: They combine, and paſs into the receiver, in a fluid which is ſomewhat turbid, and diffuſes a fœtid ſmell. It contains about a grain of ſulphur to the drachm of alcohol. I have diſcovered that the ſame combination may be produced by diſtilling ſulphureous waters, ſuch as the water of Enghien, with alcohol.

Ardent ſpirit, or alcohol, does not act at all on either metallic matters, or their oxides. It diſſolves amber in part. It produces no effects on black carbonaceous bitumens. It is obſerved, that it combines beſt with amber, after being diſtilled on fixed alkali, and that fixed alkali, mixed with this bituminous ſubſtance, renders it much

much more ſoluble, by reducing it, no doubt, to a ſaponaceous ſtate.

There are few vegetable matters on which alcohol does not act with more or leſs energy. It deſtroys the colouring part, and frequently the whole ſubſtance of extracts, when they are of an extracto-reſinous, or a reſino-extractive nature: the ſaccharine and ſaponaceous extracts combine with this fluid. Margraff has obtained, by alcohol, a ſaccharine eſſential ſalt from red beet, ſkirret, parſnip, &c. But the matters with which it combines the eaſieſt are volatile oils, the aroma, camphor, balſams, and reſins. Alcohol impregnated with the aroma of plants, is improperly called *diſtilled ſpirituous waters*. To obtain theſe fluids, diſtil alcohol on a balneum-marie with odorous plants. The liquid takes up the odorous principle, and is volatilized with it, carrying off, at the ſame time, a certain quantity of volatile oil, which cauſes it to become white with diſtilled water. But the oleaginous principle may be ſeparated, by rectifying it on a water-bath by a very moderate heat; and care muſt be taken, that no more than three fourths of the alcohol employed be drawn off, leſt ſome other ſubſtance beſides the aroma ſhould be volatilized with it. The ſmell of theſe diſtilled ſpirituous waters becomes more and more agreeable as they grow older; and it appears, that the odorous principle combines more intimately with the alcohol the longer they are in union.

So great is the affinity between the aroma and alcohol, that alcohol detaches it from volatile oils and water.—When alcohol is diſtilled on volatile oils, and on water impregnated with the odorous principle of a plant, the

alcohol

alcohol ſeizes the odorous principle, leaving the oil and the water deſtitute of ſmell. It is obſerved, that alcohol diſſolves thick and ponderous volatile oils, more readily than ſuch as are very light and fluid. Water ſeparates the principles of this compound: It precipitates the oil in the form of opaque white globules; but the aroma ſtill remains combined with the alcohol. This liquid eaſily diſſolves camphor in a cold ſtate; but it diſſolves ſtill a greater quantity of it when aſſiſted by the action of heat. This ſolution, in the proportion of two drachms of camphor to the ounce of alcohol, with water added, drop by drop, affords a cryſtalline vegetative figure, which has been obſerved by M. Romieu: It is a perpendicular filament, with needles riſing upon it, under an angle of ſixty degrees. This experiment ſucceeds but ſeldom; as it is ſo very difficult to employ preciſely the proper quantity of water, the proper degree of cooling, &c.

Compounds of oily or reſinous juices with alcohol, in which the alcohol is ſo ſtrongly charged with the oleaginous or reſinous juice, as to be coloured by it, and to afford a copious precipitate in water, are called *tinctures*, *elixirs*, *balſams*, *quinteſſences*, &c. Like diſtilled ſpirituous waters, theſe are either ſimple, as when there is only one matter diſſolved in them; or compound, when they contain ſeveral matters together. Theſe medicines are generally prepared by expoſing the juice in powder, or the dry plant, the volatile oil or reſin of which is to be diſſolved, to the action of alcohol, aſſiſted by ſtirring, and by the gentle heat of the ſun or a ſand-bath. To extract the reſins, or any other vegetable matters, from ſeveral different plants at once, care muſt be taken, firſt

to digeſt the matter which is the leaſt liable to be affected by the action of the alcohol, and then to expoſe to it, ſucceſſively, the other ſubſtances over which it has greater power. When the menſtruum is charged with as much of theſe matters as it can receive, it is ſtrained off. Sometimes a compound tincture is prepared at once, by mixing together ſeveral ſimple tinctures. In this manner, the *elixir proprietatis* is prepared, by mixing the tinctures of myrrh, ſaffron, and aloes. Reſins and balſams may be ſeparated from alcohol by pouring water upon the tinctures, or diſtilling them; but in either of theſe caſes, the alcohol retains the odorate principle. Water is not capable of decompoſing tinctures formed with extracto-reſinous, or reſino-extractive matters, ſuch as thoſe of rhubarb, ſaffron, opium, gum-ammoniac, &c.; for theſe matters are equally ſoluble in both the menſtrua.

Alcohol and brandy are very generally uſed, and applied to a great variety of purpoſes. The laſt of theſe liquors is drunk as a cordial, to revive the exhauſted ſpirits; but in exceſs it is dangerous, for it dries up the fibres, and occaſions ſhaking, palſy, and dropſy. Alcohol, either pure or mixed with camphor, is uſed to ſtop, by external application, the progreſs of gangrenes.

Diſtilled ſpirituous waters are adminiſtered in medicine, as tonics, cordials, antiſpaſmodics, ſtomachics, &c. They are given either diluted in water, or ſweetened with ſyrups.

Of theſe waters with ſugars, there are certain drinks prepared, which are known under the name of *ratafias*, or *liqueurs*. Theſe drinks, when properly prepared, and taken in ſmall quantities, may be of ſervice; but they commonly

commonly agree with very few people, and are hurtful to very many. Theſe liquors, taken in exceſs, are extremely dangerous to the human conſtitution. Inſtead of invigorating with new ſtrength, and fortifying the tone of the ſtomach, as they are commonly thought to do, they produce moſt frequently a quite contrary effect. Thoſe which, drunk but ſeldom, and with great moderation, are the leaſt injurious, are prepared cold, with one part of alcohol diſtilled upon the aromatic ſubſtance which is to afford the flavour, two parts of water, and one of the fineſt ſugar.

Tinctures have nearly the ſame virtues with diſtilled ſpirituous waters, but they act with much more energy; and therefore they are to be uſed in much ſmaller quantities, and given in wine, in potions, and even in aqueous liquors. The precipitate which they yield in the laſt of theſe, is equally ſuſpended through the mixture, and beſides the odorous part remains diſſolved in the alcohol.

Laſtly, Alcohol combined with the copal reſin, with oil of aſpic, or the greater lavender, or with oil of turpentine, forms *varniſhes*, which are called *drying*; becauſe, when a coat of this compound is laid on any body to varniſh it, the alcohol is ſoon volatilized, and leaves on the varniſhed body a tranſparent reſinous plating. The volatile oils, which are mixed with this compoſition, hinder the varniſh from drying too haſtily, and, by communicating to it ſomewhat of an unctuous nature, render it leſs brittle than it would otherwiſe be.

CHAP. XXIV.

Of Acetous Fermentation, and of the Acetous and the Acetic Acids.

MANY vegetable ſubſtances are ſuſceptible of acetous fermentation. Of this kind are gums, and amylaceous fæcula diſſolved in boiling water; but ſpirituous and fermented liquors poſſeſs this property in the moſt eminent degree. Acid fermentation may be excited in any of theſe fluids, by expoſing them to the action of heat and air at the ſame time, ſo as to convert them into what is called *vinegar*. This liquor is chiefly prepared from the wine of grapes; but very good vinegar might be alſo prepared from cyder, perry *, &c.

There are three conditions neceſſary to vinous fermentation: 1. A heat of twenty or twenty-five degrees of Reaumur's thermometer, or from 75° to 90° of Fahrenheit's: 2. A ſubſtance at once viſcous and acid, ſuch as mucilage and tartar: 3. The contact of air. The change

* Vinegar is made in Britain from wort, the infuſion of malt.

change which wines undergo, when converted into vinegar, can be attributed to nothing but an inteſtine motion, excited in thoſe bodies in conſequence of their containing a certain quantity of mucilaginous matter, unaltered, and ſtill ſuſceptible of another fermentation. The preſence of an acid matter, ſuch as tartar, is requiſite to produce acid fermentation. Laſtly, The contact of air is indiſpenſibly neceſſary; and it appears,—it has indeed been proved by the Abbé Rozier, that the liquor abſorbs a portion of air while it ferments; this is probably oxigene.

All kinds of wine are equally good for making vinegar. The worſt are preferred, becauſe they are the cheapeſt. But the experiments of Beccher and Cartheuſer ſhew, that generous wines, not deſtitute of ſpirit, afford generally the beſt vinegar.

Boerhaave, in his Elements of Chemiſtry, has given a very good proceſs for the preparation of vinegar. Take two caſks: at ſome diſtance from the bottoms of theſe caſks, form within each of them a falſe bottom of wicker-work: upon this falſe bottom ſpread grape-ſtalks and vine-branches; pour upon theſe wine, till one of the caſks be entirely full, and the other half-full. The fermentation will firſt begin in the latter: when it is fairly commenced, fill up this caſk with wine from the other: by this means, the fermentation is moderated in the full caſk, and begins in the other. After it has continued for a due length of time, fill up the latter caſk again, from the caſk in which the fermentation firſt began:—thus the fermentation is again excited in the former, and becomes languid in the other. The two caſks are to be thus ſucceſſively filled up and emptied, till ſuch

time as the vinegar be entirely formed; which is not, uſually, in leſs than fifteen days.

In obſerving the phænomena of this fermentation, we perceive a good deal of boiling and hiſſing:—The liquor becomes hot and turbid; and a great many bubbles and filaments appear to run through it in all directions: there exhales from it a lively acid ſmell, which is in no way dangerous: it abſorbs a great deal of air. There is a neceſſity for ſtopping the fermentation every twelve hours: by degrees theſe phænomena diſappear; the heat falls, the emotion ceaſes, and the liquor becomes clear. It depoſites a glareous ſediment, in reddiſh flakes, which ſtick to the ſides of the caſks. It appears, from a ſufficient number of experiments, that the ſmaller the quantity of the wine, and the more it is expoſed to the contact of air, ſo much the more readily does it paſs into the ſtate of vinegar. Care muſt be taken to draw off the vinegar clear, when it is thus prepared, in order to ſeparate the lee, which, were this precaution neglected, would cauſe it to paſs into the ſtate of putrid fermentation.—Vinegar does not, like wine, depoſite tartar by reſt: this ſalt was diſſolved, and combined with the alcohol and water, during the fermentation. It is even probable, that the preſence of this ſalt has a principal influence in calling forth the properties of vinegar from a latent ſtate. This vinegar is of a lighter or an higher colour, according to the nature of the wine from which it is prepared: but even the lighteſt coloured vinegar is generally much higher coloured than any ſort of white wine; becauſe the colouring part of the tartar, which has been called forth from a latent ſtate by the production of the acid, is diſſolved in it.

Vinegar

Vinegar prepared in the manner above deſcribed is extremely fluid, of an acid ſpirituous ſmell, and of a taſte in a greater or a leſs degree ſour. It reddens blue vegetable colours. When expoſed to a moderate heat, in veſſels indifferently ſtopped, it is altered, loſes its ſpirituous part, depoſites a great deal of mucilaginous flakes and filaments, and aſſumes a putrid taſte and ſmell. M. Scheele has ſhewn, that it muſt be boiled for a few minutes, in order that it may be preſerved unſpoiled.

When vinegar is diſtilled by naked fire, in a ſtone cucurbite covered with a capital, or in a glaſs-retort on a ſand-bath, it affords a phlegm of a lively and agreeable ſmell, ſcarcely acid; to which immediately ſucceeds a very white, and ſtrongly odorous acid liquor: this is diſtilled vinegar: What follows is leſs odorous, but more acid; and the farther the proceſs advances, the more acid does the product become.—Theſe ſeveral products may be taken ſeparately; by which means, ſo many different ſorts of diſtilled vinegar will be obtained, of various degrees of acidity and ſmell. The operator muſt be ſatisfied with obtaining two thirds of the liquor, which forms the pureſt vinegar. The portion which paſſes after this, is more acid; but it has an empyreumatic ſmell, which may be removed by expoſing it to the air. It likewiſe acquires a faint colour. This operation ſhews the acetous acid to be more ponderous than water. The reſidue is thick, and of a dirty, deep-red colour. It depoſites a certain quantity of tartar, and is in an high degree acid.—Evaporated over an open fire, it takes the form of an extract; and if, when dry, it be diſtilled in a retort, it affords an acid reddiſh phlegm, an oil which is at firſt light and coloured, but becomes after-

wards ponderous; with a little ammoniac.—The reſidual coal, now left, contains a conſiderable proportion of fixed alkali.

Vinegar may be concentrated by expoſing it to froſt.—That portion which ſtill remains liquid becomes highly acid, and is decanted off. The frozen part is almoſt entirely water. Only a very little vinegar is obtained by this operation.

The acid of vinegar, when ſeparated from tartar and from its colouring part by diſtillation, is ſuſceptible of combination with a great number of bodies.

It combines only in an imperfect manner with aluminous earth, and forms with it needled cryſtals, the properties of which are but very little known. The name of this ſalt (in the new Nomenclature) is *Acetite of alumine.*

It combines readily with magneſia, affording in the combination a ſalt, which is extremely ſoluble in water, and does not cryſtallize, but affords, by evaporation, a viſcid, deliqueſcent maſs. Acetite of magneſia is decompoſable by fire, by mineral acids, by barytes, by lime, and by the three alkalis.—It is very ſoluble in alcohol.

The acetous acid combines with lime; and decompoſes chalk, diſengaging its acid in the form of an elaſtic fluid.—The ſalt which it forms with lime cryſtallizes into very fine needled cryſtals, of a gloſſy appearance, like ſatin.—Calcareous acetite is ſour and bitter: it efloreſces in the air. It is decompoſed by fire; by fixed alkalis, which ſeparate the earth; and by mineral acids, which diſengage the acid.

The

The combination of the acetous acid with potaſh, is improperly called, in the laboratories, *foliated earth of tartar*: it ſhould be denominated, *acetite of potaſh.* In preparing this ſalt, a quantity of very pure diſtilled vinegar is poured upon carbonate of potaſh, prepared by the incineration of tartar; the mixture is ſtirred, and vinegar is poured in, till the ſalt be fully diſſolved, and the two ſubſtances mutually ſaturated:—there ſhould rather, indeed, be an exceſs of the acid.—This liquor is filtrated, and evaporated by a very moderate fire, in a veſſel of porcelain or pure ſilver. When it becomes thick, the evaporation is continued on a water-bath till it be quite dry. By this means a very white ſalt is obtained.—If expoſed to too much heat, it takes a grey or a brown colour, becauſe a portion of the vinegar is burnt.—Some chemiſts affirm, that acetite of potaſh may be obtained in a regular form, by ſuffering the ſolution to cool after having evaporated it to a thick pellicle.

Acetite of potaſh is of a pungent, acid, urinous taſte.—By the action of fire it is decompoſed, ſo as to afford, in the retort, an acid phlegm, an empyreumatic oil, ammoniac, and a large quantity of ſtrong ſmelling gas, conſiſting of carbonic acid, with hydrogenous gas. The reſidual coal contains a good deal of naked potaſh.—This ſalt ſtrongly attracts the moiſture of the atmoſphere, and is very ſoluble in water. The ſulphuric acid decompoſes it. To effect this decompoſition, one part of concentrated ſulphuric acid is poured on two parts of acetite of potaſh, introduced into a tubulated glaſs-retort, with a receiver fitted to it. There is inſtantly diſengaged, with a lively efferveſcence, a vaporous fluid,

of a poignant ſmell, which, in the receiver, condenſes into acetic acid, the *radical* principle of *vinegar*. This vinegar is highly concentrated, and ſtrongly acid, but not pure, and always mixed with a certain quantity of ſulphureous acid, which may be diſtinguiſhed by its ſmell.—The tartareous acidulum likewiſe decompoſes acetite of potaſh; becauſe it has a nearer affinity than the acetous acid with the alkaline baſe of this ſalt.

Vinegar enters into a perfect combination with ſoda, and forms with it a ſalt which has been improperly called *cryſtallizable foliated earth*: We give it the denomination of *acetite of ſoda*. The only difference between this ſalt and acetite of potaſh, is, that it cryſtallizes in ſtriated priſms, much like thoſe of ſulphate of ſoda, and does not attract moiſture from the atmoſphere. To obtain it in regular cryſtals, its ſolution muſt be evaporated to a pellicle, and then ſet in a cool place. Acetite of ſoda, like acetite of potaſh, is decompoſable by fire, and by mineral acids. To theſe particulars we may add, that when alkaline acetous ſalts are diſtilled by a ſtrong fire, the reſidues which they leave are ſo many pyrophori, and burn when expoſed to the air. M. Prouſt, to whom we owe theſe diſcoveries, thinks the diviſion of a carbonaceous reſidue, by an earth or a metallic oxide, to be the only condition neceſſary to the production of a pyrophorus.

The acid of vinegar forms, with ammoniac, a liquor that is called *ſpirit of Mendererus*, and is properly ammoniacal acetite. This ſalt is ſo volatile that it cannot be evaporated without a great part of it being loſt; yet, by ſlow evaporation, it may be obtained in needled cryſtals, which are of a hot pungent taſte, and very ſpeedily attract

attract moiſture from the atmoſphere. Ammoniacal acetite is decompoſed by the action of fire; by lime and alkalis, which diſengage the ammoniac; and by mineral acids, which ſeparate the acetous acids.

Vinegar acts upon almoſt all metallic ſubſtances; and exhibits, in its combinations with them, a number of very important phænomena.

It does not appear that this fluid is capable of effecting an immediate ſolution of oxide of arſenic; but this oxide, by diſtillation with equal parts of acetite of potaſh, afforded M. Cadet, and the chemiſts of the Academy of Dijon, a fuming liquor of a very ſtinking ſmell, very tenacious, and of a very ſingular nature. M. Cadet firſt obſerved this liquor to be capable of inflaming fat lute. The academicians of Dijon, wiſhing to examine a yellowiſh matter of an oleaginous conſiſtency, which they found accumulated in the bottom of a bottle containing arſenico-acetous fuming liquor, decanted off a part of the ſupernatant liquor, and poured the reſt on a paper-filter. Only two or three drops had paſſed, when ſuddenly there aroſe a very thick ſmoke, of a nauſeous ſmell, which formed a column extending from the veſſel to the cieling of the room: a ſort of ebullition took place around the edges of the matter, and from it there aroſe a beautiful roſe-coloured flame, which continued to burn for ſeveral ſeconds. A particular account of theſe elegant experiments may be ſeen in the third volume of the *Elements of Chemiſtry* of Dijon. Theſe chemiſts compare the liquor of which we are ſpeaking to a liquid phoſphorus: We take it to be a ſort of pyrophorus, as well as ſome others of which we are hereafter to ſpeak. The reſidue remaining after the diſtillation of

acetite of potaſh, with oxide of arſenic, conſiſts chiefly of potaſh.

Vinegar diſſolves oxide of cobalt: the ſolution is of a pale roſe-colour.

It acts neither on biſmuth, nor on its oxide; but diſſolves oxide of manganeſe.

It accompliſhes a direct ſolution of nickel, according to M. Arwidſſon. This ſolution affords green cryſtals, of the form of a ſpatula.

This acid does not act upon antimony; but it appears to diſſolve the vitreous oxide of that ſemi-metal; for Angelus Sala made up an emetic preparation of theſe two ſubſtances.

Both zinc and its oxide diſſolve very readily in diſtilled vinegar. M. Monnet obtained, by evaporating this ſolution, cryſtals in the form of broad plates. Acetite of zinc fulminates on the coals, and gives out, on the occaſion, a faint bluiſh flame. It affords, by diſtillation, an inflammable liquor, a yellowiſh oily fluid, the colour of which ſoon changes to a deep green, and a white ſublimate, which burns by the light of a taper, with a beautiful blue flame. The reſidue is in the ſtate of a ſcarcely combuſtible pyrophorus.

The acid of vinegar does not diſſolve mercury in a metallic ſtate. This combination may, however, be effected by attenuating the mercury into very ſmall particles in the manner of Keyſer. Mercury, in the ſtate of oxide, combines eaſily with vinegar. The only thing neceſſary to produce this combination, is, to boil the acid upon the red oxide of mercury, called *precipitate per ſe*, upon *turbith*, or upon mercury, precipitated by potaſh from a nitric ſolution of that metal. The liquor becomes

comes white, but regains its tranſparency while boiling. It is filtrated. By cooling it precipitates ſilver-coloured cryſtals, in the form of ſparkling ſcales, reſembling the cryſtals of the boracic acid. This acetite of mercury has obtained the name of *mercurial foliated earth*. It is prepared in an inſtant, by pouring a nitric ſolution of mercury into a ſolution of acetite of potaſh. The nitric acid combines with the fixed alkali of the latter of theſe ſalts, and forms with it nitre, which remains diſſolved in the liquor; and the oxide of mercury, combining with the acid of vinegar, is precipitated in brilliant ſcales. This mixture is filtrated; and the acetite of mercury then remains on the filter. This ſalt is decompoſed by the action of fire. Its reſidue affords a ſort of pyrophorous. It is eaſily altered by combuſtible vapours.

Tin ſuffers but very little alteration from vinegar. This acid diſſolves only a very ſmall portion of the metal. The ſolution afforded M. Monnet, by evaporation, a yellowiſh ſubſtance reſembling gum, and of a fœtid ſmell.

Lead is one of thoſe metals on which the acid of vinegar acts with the moſt powerful energy. It diſſolves this metal with the greateſt facility. Plates of lead, expoſed to the ſteam ariſing from hot vinegar, are covered over with a white duſt, which is called *ceruſe*, and is nothing but oxide of lead, with a little vinegar. This oxide, ground with one-third part of chalk, forms what is uſed in painting under the name of white lead. To ſaturate vinegar with lead, the acid is poured upon *ceruſe* in a matraſs. This mixture is digeſted on a ſand-bath. After remaining in digeſtion for ſeveral hours,

the

the liquor is filtered and evaporated to a pellicle. It affords, by cooling and reſt, white cryſtals,—in the ſhape of irregular needles, if the liquor was too much concentrated,—or of flat parallelipipeds, terminating in two ſloping ſurfaces, when the proceſs of evaporation is properly conducted. This acetite of lead is called *ſal* or *ſaccharum Saturni*, on account of its ſaccharine taſte. Its taſte is likewiſe ſtiptic. A ſimilar ſalt is prepared of litharge and vinegar. Equal parts of the two ſubſtances are boiled together till they be mutually ſaturated; and this mixture, after being evaporated to the conſiſtency of clear ſyrup, forms M. Goulard's *extract of Saturn*, which was known long before his time by the name of *vinegar of Saturn*. Acetite of lead is decompoſed by heat. It affords an acid liquor, which is ruddy, and ſtrongly fœtid, but very different from radical vinegar, or the pure acetic acid of which we are ſoon to ſpeak. The reſidue is a very good pyrophorus. This ſalt is decompoſed by diſtilled water, by lime, alkalis, and mineral acids. The *extract of Saturn*, diluted in water, and mixed with a little brandy, forms the *vegeto-mineral* water.

Vinegar diſſolves iron with conſiderable energy. The effervescence which takes place in this ſolution is owing to the diſengagement of hydrogenous gas from the water which appears to be decompoſed. The liquor aſſumes a red or brown colour. By evaporation, it affords nothing but a gelatinous magma, mixed with a few oblong brown cryſtals. Acetite of iron has a ſtiptic ſweetiſh taſte. It is decompoſed and deprived of its acid by fire. It attracts moiſture from the atmoſphere, and is decompoſed in diſtilled water. When heated till it ceaſes to exhale

exhale the ſmell of vinegar, it then leaves a yellowiſh oxide, ſubject to the attraction of the loadſtone. The acetous ſolution of iron affords with nut-gall a very black ink, and might be very advantageouſly employed in dyeing. Alkaline Pruſſiates precipitate from it a very bright Pruſſian blue. Black, yellow, and brown oxide of iron, and native carbonate of iron, or *ſpathoſe iron-ore*, afford with vinegar ſolutions of a very beautiful red colour.

Copper is very eaſily diſſolved in the acetous acid. This ſolution, with the help of heat, takes by degrees a green colour. But the acid acts more readily on this metal, when it has been already oxidated by vinegar, and ſo converted into the ſubſtance called *verdigris*. Verdigris is prepared in the neighbourhood of Montpellier, by laying plates of copper into earthen veſſels, in layers covered with the huſks of grapes, previouſly ſprinkled and fermented with weak vinegar. The ſurfaces of theſe plates are ſoon covered with a green ruſt; which is increaſed by piling them upon each other, and ſprinkling them with weak vinegar. The copper is then ſcraped, and the verdigris put up in leather-bags for ſale. M. Montet, an apothecary at Montpellier, has given a very good deſcription of this proceſs in two Memoirs, printed among the Memoirs of the Academy of Sciences, in the years 1750 and 1753. Verdigris readily diſſolves in vinegar. This ſolution is of a beautiful green colour, and affords, by evaporation and cooling, green cryſtals in truncated quadrangular pyramids, which are called *cryſtals of Venus*. The cryſtals prepared for commerce, which are called *diſtilled verdigris*, on account of their being prepared with

with diſtilled vinegar, are in the form of fine pyramids. Theſe cryſtals take a pyramidal form, from their being depoſited on a piece of wood ſplit into four branches, which are kept ſeparate by a piece of cork.

Acetite of copper has a very ſtrong taſte, and is a violent poiſon. It is decompoſed by the action of fire. It efferveſces in the air, and is covered over with a duſt, the colour of which is a much paler green than the colour of the original ſalt. It is entirely diſſolved in water, but not decompoſed. Lime-water and alkalis precipitate this ſolution.

When this ſalt is reduced to powder, and diſtilled in a glaſs or earthen retort, with a receiver, it affords a fluid, which is at firſt white and ſomewhat acid, but ſoon becomes ſo ſtrong as to be not inferior in acidity to concentrated mineral acids. The receiver is changed, in order that the phlegm and the acid may be obtained ſeparate. The acid has been called *radical vinegar*, or *vinegar of Venus*. It is of a green colour, which it owes to a certain quantity of calx of copper that is carried up with it in the diſtillation. When the diſtillation ceaſes, and the retort is red-hot, the reſidue remaining is a brown copper-coloured duſt, which frequently communicates a metallic tinge to the ſides of the veſſel. This reſidue, as has been obſerved by the Duke d'Ayen, and M. Prouſt, is ſtrongly pyrophoric. *Vinegar of Venus* is rectified by diſtillation with a moderate heat. It is then perfectly white, provided it be not too much urged with fire towards the end of the operation, ſo as to reduce the oxide of copper, remaining in the retort, to too dry a ſtate. The reduction of copper

which may be obſerved in this operation, contributes to explain the nature of *radical vinegar*. This acid appears to bear the ſame relation to common vinegar which the oxigenated muriatic acid bears to the pure muriatic acid;—or rather, the ſame which the ſulphuric bears to the ſulphureous acid, or the nitric to the nitrous acid. In this operation, the acetous acid combines with the oxigene of the oxide of copper, which paſſes at the ſame time into a metallic ſtate. The effects, in the production of which *radical vinegar* differs eſſentially from common vinegar, ſeem to be owing to the oxigene which that acid acquires. For this reaſon, we give it, according to the rules of the Nomenclature now adopted through this work, the name of the *acetic acid*.

The acetic acid, or radical vinegar, rectified in this manner, is of ſo lively and pungent a ſmell, that it can ſcarce be borne. Such is its cauſticity, that when applied to the ſkin it corrodes and cauterizes it: it is extremely volatile and inflammable: when heated in contact with air, it takes fire, and burns with more or leſs rapidity, according as it is more or leſs rectified. This fact has led chemiſts to think, that vinegar contains alcohol, and is a ſort of natural æther. The poignant agreeable ſmell which the firſt portions of this acid diffuſe, favours the ſame opinion.

Acetic acid evaporates all away in the air. It combines with water, with a conſiderable heat: with earths, alkalis, and minerals, it forms ſalts different from thoſe into which common vinegar enters; we call them *acetates* of potaſh, ſoda, zinc, mercury, &c. M. de Laſſone has ſhewn, that the ammoniacal ſalt formed by radical vinegar,

vinegar, or the acetic acid, is not of the ſame nature with ammoniacal acetite, or ſpirit of Mendererus. Although we are not yet ſufficiently acquainted with all theſe acetates; yet their form, taſte, and ſolubility, ſhew plainly, that they are of a different nature from acetites.

The Marquis de Courtanvaux has ſhown, that nothing but the laſt portion of the acetic acid, obtained by the diſtillation of acetite of copper or *verdigris*, is ſuſceptible of inflammation, and that it poſſeſſes likewiſe the property of being liable to congelation by cold. This laſt portion, rectified, cryſtallized in the receiver, in large plates, and in needles; nor did it become fluid, till it was expoſed to a heat thirteen or fourteen degrees above the freezing point. In this property, this ſubſtance reſembles oxigenated muriatic acid.

The acetic acid decompoſes alcohol, and forms æther, as readily as mineral acids, as has been diſcovered by the Count de Lauraguais. All that is neceſſary to produce this effect, is to pour a quantity of radical vinegar upon an equal quantity of alcohol. A conſiderable heat is excited. The retort is placed upon a hot ſand-bath; and two receivers are adapted to it, the moſt diſtant of which is immerſed in cold water or pounded ice. This mixture muſt be quickly boiled. There ariſes from it, firſt, a dephlegmated alcohol; after that, æther; and then an acid, which becomes gradually ſtronger, as the proceſs advances. In the retort there remains a brown maſs, much like a reſin. Care muſt be taken to change the receiver as ſoon as the ſmell of the æther becomes acrid and pungent, and to collect the acid by itſelf. The acetic æther, thus obtained, muſt be rectified by a moderate

moderate heat with potaſh. In this operation there is a good deal of it loſt. The formation of this æther is owing to radical vinegar's containing an exceſs of oxigene. Scheele relates, that he never ſucceeded in preparing acetic æther from radical vinegar combined with alcohol, and could not accompliſh this preparation without adding a mineral acid. M. Pærner had already made the ſame remark on the difficulty of obtaining acetic æther by M. de Lauraguais's proceſs. A great many French chemiſts have, however, employed this proceſs, and I myſelf, among others, with ſufficient ſucceſs.

M. de La Planche, apothecary, prepares acetic æther by pouring concentrated ſulphuric acid and alcohol upon acetite of lead introduced into a retort. The theory and practice of this operation differ in no reſpect from thoſe of the analogous proceſs by which nitric and muriatic æther are prepared. Acetic æther has, like every other ſort of æther, an agreeable ſmell, which, however, is always mixed with the ſmell of vinegar, though not acid. It is very volatile and inflammable, burns with a lively flame, and leaves, after its combuſtion, a carbonaceous mark.

Chemiſts need to make yet many more reſearches into the nature of the acetic acid. What we have here ſaid concerning its properties, will ſerve to ſhew, 1. That it differs in a ſingular manner from the acetous acid, or common vinegar. 2. That the difference is owing to the acetic acid's containing more oxigene than the acetous; which exceſs it has derived from the oxide of copper.—Let us now reſume the examination of the other properties of common vinegar.

The acetous acid, with the help of heat, diſſolves the gold precipitated by fixed alkali, from the oxigenated muriatic acid. This acetous ſolution of gold, precipitated by ammoniac, affords *fulminating gold*, as has been ſhown by Bergman. It acts in the ſame way on platina and ſilver. While theſe metals are in a matallic ſtate, vinegar is incapable of acting upon them; but it diſſolves them, when expoſed to it in the ſtate of oxides.

Vinegar is capable of combining with many of the immediate principles of vegetables: It diſſolves extracts, mucilages, and eſſential ſalts It combines with the aroma: It is thought to be the proper ſolvent for gum reſins. It has even, at length, or by the way of diſtillation, a diſcernible influence on fat oils, and reduces them to a ſort of ſaponaceous ſtate. The combinations of vinegar with vegetable ſubſtances have not been farther examined with any accuracy.

This acid is uſed in the extraction of ſeveral of the principles of vegetables, eſpecially in the extraction of their odoriferous principle; and various ſorts of vinegar, both ſimple and compound, are prepared for medical uſes. Vinegar of ſquills, colchicum, &c. afford inſtances of the ſimple; theriacal vinegar, and the vinegar of the four thieves, are compounds. Theſe medicines are prepared by maceration and digeſtion, continued for ſeveral days. As this acid is volatile, it is diſtilled on aromatic plants, whoſe odoriferous principle it takes up. Of this kind is the diſtilled vinegar of lavender, which is uſed at the toilet. Theſe liquors are, in general, not ſo agreeable as ſpirituous diſtilled waters.

Vinegar is very much uſed as an article of ſeaſoning. It is much uſed in medicine, as being cooling and anti-

ſeptic

ſeptic: There is a ſyrup made up of ſugar and vinegar, which is adminiſtered with ſucceſs in burning and putrid fevers, &c. This acid, applied externally, is aſtringent and reſolvent. All its combinations are, in like manner, uſed as excellent medicines.

Acetite of potaſh, and acetite of ſoda, which are known by the names of *terra foliata tartari*, and *acetous mineral ſalt*, are powerfully diſcuſſive and aperient: They are given in doſes of half a drachm, or even a drachm each.

Spirit of Mendererus, or ammoniacal acetite, given in doſes of a few drops, in certain drinks, is aperient, diuretic, cordial, antiſeptic, &c. It is often ſucceſsful in the leucophlegmatia, or ſwelling of the external parts of the body.

Acetite of mercury, or *terra foliata tartari*, is an excellent anti-venereal: it is the principal ingredient in Keyſer's pills.

The *extract of Saturn*, *vinegar of Saturn*, and *vegeto-mineral* water, are applied externally, as deſiccatives. They are violently repercuſſive, and ought therefore to be very cautiouſly adminiſtered, eſpecially when applied to excoriated or ulcerated parts. Boerhaave mentions ſeveral young women who were attacked with conſumptions, in conſequence of the external uſe of preparations of lead.

Ceruſe enters into the compoſition of deſiccative unguents and plaſters; and *verdigris* into ſeveral collyria and unguents.

The acetic acid, or *radical vinegar*, is given as a very active, irritating, and ſtimulating medicine. It is held

to the noſtrils of perſons in fainting-fits. In order that it may be the more conveniently made uſe of, a certain quantity of this acid is poured on ſulphate of potaſh in a coarſe powder, and put into a cloſe-ſtopped phial. This medicine is well known in the world, under the name of *ſalt of vinegar*.

Acetic æther has not yet been applied to uſe; and it is not known whether it poſſeſſes any virtues different from thoſe of the other ſorts of æther.

CHAP.

CHAP. XXV.

Of the Putrid Fermentation of Vegetables.

ALL vegetable ſubſtances that have ſuffered the ſpirituous and the acid fermentation, are ſtill liable to undergo another inteſtine motion, which is called *putrid fermentation*. Stahl and ſeveral other chemiſts think this fermentation to be nothing but a conſequential part of the two other fermentations already deſcribed;—or rather, that the phænomena of all the three ariſe from *one* internal emotion, the tendency of which is to deſtroy the texture of the ſolids, and to alter the nature of the fluids. It is in fact obſervable, that certain vegetable ſubſtances paſs, of themſelves, through three ſucceſſive fermentations. For inſtance, all ſaccharine matters, diluted in a certain quantity of water, and and expoſed to a heat of—from 60 to 80 degrees, afford, firſt wine, then vinegar, and at laſt loſe entirely their character of acidity: they are altered, become putrid, loſe all their volatile principles, and are in the end re-

duced to a dry, inſipid, earthy ſubſtance. It is to be obſerved, however, that a great number of vegetable ſubſtances are not, in any ſenſible manner, liable to paſs ſucceſſively through theſe three ſorts of fermentation, in the above-mentioned order. Inſipid mucilages and gums diſſolved in water paſs into an acid, without becoming diſcernibly ſpirituous: the glutinous matter again ſeems to paſs, all at once, into a ſtate of putrefaction, without becoming acid. It appears, then, that although in ſeveral of the principles of vegetables, theſe three fermentations follow each other in regular ſucceſſion, yet many of thoſe principles are ſuſceptible of the two latter ſpecies of fermentation, without having previouſly undergone the former; nay, are even liable to putrefaction, without becoming previouſly acid. Thoſe of the laſt mentioned character partake of the nature of animal ſubſtances, and accordingly afford ammoniac by the action of fire, and azotic gas by the acid of nitre. It is in conſequence of their poſſeſſing ſuch characteriſtics, that theſe vegeto-animal ſubſtances putrefy ſo readily.

Certain conditions, well worthy of our attention, are requiſite, in order that the inteſtine motion which changes the nature of vegetable matters, and reduced them to their elementary principles, may take place. Humidity, or the preſence of water, is one of the moſt indiſpenſable of theſe conditions. Dry ſolid vegetables, ſuch as wood, ſuffer no alteration while they continue in that ſtate; but if they be moiſtened, and their fibres ſeparated, an inteſtine motion then commences. Water appears, therefore, to be one of the cauſes of putrefaction. And when we come to examine the animal kingdom, we will have occaſion to ſee, that the inteſtine motion

with

with which putrefaction begins is owing to the decompoſition of that liquid. Heat is not leſs neceſſary to putrefaction. Cold, or the temperature of ice, is not only adverſe to this ſpontaneous deſtruction in ſubſtances which have not yet begun to ſuffer from it, but even retards its progreſs, and, in ſome meaſure, reverſes it where it has already begun to operate. The degree of heat neceſſary to putrefaction, is much inferior to what is required for the ſpirituous and the acid fermentation; for putrefaction takes place at the temperature of 45 degrees; but a more conſiderable heat is ſtill more favourable; at leaſt, if it be not ſo violent as to volatilize all the moiſture of the putreſcent ſubſtance, and render it entirely dry. Acceſs of air is another condition, ſingularly favourable to putrefaction; for vegetable ſubſtances are very well preſerved *in vacuo*. The contact of air, however, is not ſo indiſpenſably neceſſary to putrefaction as the two other conditions already mentioned; for this phænomenon ſometimes takes place without its aſſiſtance.

The putrefaction of vegetables exhibits peculiar phænomena. Vegetable fluids, when they putrefy, become turbid, loſe their colour, and depoſite various ſediments: bubbles aſcend to the ſurface, and mouldineſs gathers over it in the beginning of the alteration. Soft vegetable matters exhibit the ſame phænomena, on being ſimply wet. The emotion then produced is at no time ſo conſiderable as that which appears in the caſes of ſpirituous and acetous fermentation. The putrefying body does not appear to increaſe in bulk, nor does its temperature become higher. But the principal phænomenon of putrefaction is, change of ſmell, with the volatilization

of an urinous, pungent, acrid principle,—in a word, ammoniac. From this circumſtance, putrefaction has been called *alkaline fermentation*, and ammoniac conſidered as its product. The pungent ſmell exhales by degrees, and is ſucceeded by a nauſeous inſipid ſmell, which can ſcarce be deſcribed. The decompoſition has now attained its height: The putrid vegetable maſs is become very ſoft, like a jelly; it ſinks down, and the odorous principle exhaling from it ſuffers a great many ſucceſſive modifications. At laſt it becomes dry, and loſes, by degrees, its diſagreeable ſmell; and what remains is nothing but a blackiſh, and ſeemingly carbonaceous reſidue, known by the name of *humus vegetabilis*, which is found to contain nothing but ſaline and earthy ſubſtances. Such is the order of the phænomena that are ſucceſſively obſerved in the ſpontaneous decompoſition of putrefying vegetables. But this proceſs of decompoſition, when carried ſo far as to reduce the vegetable body to an earthy or ſaline reſidue, is extremely tedious, and, we may even add, has never yet been obſerved by any perſon with ſuitable attention. Chemiſts and naturaliſts have paid ſtill leſs attention to the putrefaction of vegetable, than to that of animal ſubſtances. No philoſopher has hitherto undertaken to obſerve all the phænomena of the putrefaction of vegetables, but many have begun to deſcribe thoſe which attend the putrefaction of animal matters. Here, therefore, it appears proper for us to conclude our hiſtory of the ſpontaneous and natural decompoſition of vegetables with the following obſervations: 1. The little which we have here ſaid concerning it is ſufficient to ſhow, that the putrefaction of vegetables attenuates, volatilizes, and de-

ſtroys

ſtroys all their humours, and reduces them to an earthy ſtate: 2. We have as yet no certain knowledge of the phænomena and the limits of this ſpecies of putrefaction, which is to be carefully diſtinguiſhed from the putrefaction of animal matters: 3. Laſtly, As this fermentation is much more conſpicuous, and has been much more attentively obſerved in the humours and ſolids of animals; the more extenſive detail of particulars which we are to give, in our account of animal ſubſtances, will complete the ſketch which we have here marked out, and conclude the hiſtory of thoſe facts that are known concerning putrefaction.

PART

PART FOURTH.

THE ANIMAL KINGDOM.

CHAP. I.

Of the Chemical Analyſis of Animal Subſtances in general (1).

IN the analyſis of animal ſubſtances, we meet with greater difficulties than in any other part of chemiſtry; and our chemical knowledge of thoſe ſubſtances is accordingly in a more imperfect ſtate than any other branch of the ſcience. The ancient chemiſts were content with diſtilling them by naked fire; an operation which is at preſent known to alter and totally deſtroy the nature of ſuch compound bodies as the ſolids or fluids of animals. The only parts of animals that have yet

(1) In the ſecond edition of this Work, the animal kingdom began with a brief account of the nature of animals, the diſtinctions ſubſiſting among them, the methods requiſite for marking out thoſe diſtinctions in Natural Hiſtory, and the Natural Philoſophy of Animals. The mode of arrangement now adopted in theſe volumes, and the little connection between the natural deſcription of animals, and the chemiſtry of animal matters, have induced me to remove that part into a fifth volume. A.

yet been ſubjected to an analyſis, are ſome of the humours of the human body, and the humours of certain quadrupeds.

Many circumſtances have concurred to retard the progreſs of this branch of chemiſtry. The difficulty and diſagreeableneſs attending reſearches of this kind; the imperfection of the chemical methods with which, till within theſe few years, animal matters were always treated, and which conſtantly produced on them great alterations; the impoſſibility which was always found of approaching near to a reproduction of any animal matter by ſyntheſis; and, above all, the ſmallneſs of the inducements which any but medical chemiſts could have to engage in ſuch reſearches; are the principal reaſons which have prevented the enlargement of this department of the ſcience of chemiſtry. But the reſearches of ſeveral moderns, eſpecially of Meſſrs Rouelle, Macquer, Bucquet, Poulletier de la Salle, Berthollet, Prouſt, Scheele, and Bergman, have here opened a new tract of diſcovery, and ſhew, that the art of healing may derive the moſt ſignal advantages from reſearches of this kind.

The human body, and the bodies of quadrupeds—the principal animals which engage our attention—are compoſed of fluids and ſolids. The humours of animals are divided into three claſſes, according to the purpoſes for which they ſerve. The firſt contains the recrementitial humours, the uſe of which is to nouriſh certain organs: the ſecond comprehends excrementitial humours, which are evacuated by certain emunctories, as uſeleſs, and even noxious, when retained too long within the body: the third claſs conſiſts of humours to which the

characteriſtics of both the two former claſſes belong; they being partly recrementitial, and partly excrementitial. To the firſt claſs belong the blood, the lymph, the jelly or gelatinous part, the fibrous or glutinous part, the fat, the marrow, the matter which ſupports interior perſpiration, and the oſſeous juice. The ſecond claſs conſiſts of the fluid which is inſenſibly tranſpired by the pores, the ſweat, the mucus of the noſtrils, the cerumen of the ears, the gummy matter of the eyes, the urine, and the fæces. Thoſe of the third claſs are, the ſaliva, the tears, the bile, the pancreatic juice, the gaſtric and inteſtinal juices, the milk, and the ſeminal liquor. We cannot examine all theſe fluids in the order in which they are here mentioned: 1. Becauſe they are ſtill but very little known; 2. Becauſe it is abſolutely neceſſary that we treat firſt of ſuch as have been the moſt completely analyſed.

The ſolids of animals, which form the parenchyma of their different organs, may be divided into three claſſes. In the firſt of theſe claſſes I rank the ſoft white parts, ſuch as the laminæ of the cellular tiſſue, the membranes, the membranous viſcera, the aponeuroſes, the ligaments, the tendons, and the ſkin. The ſoft red parts form a ſecond claſs, very different from the former; ſuch are, particularly, the muſcles, and a part of the organs which contain muſcular fibres, as the ſtomach, the inteſtines, the bladder, the matrix, &c. Laſtly, the third claſs comprehends the oſſeous or bony ſolids.

Animal matters are at preſent analyſed in a very different way from that in which they were analyſed a few years ſince. They are no longer ſubjected to decompoſition by fire; they are now treated by re-agents, particularly

particularly acids, alkalis, alcohol, &c. The different fluids intermingled with each other, or contained in the veſicles of the different parts, are ſeparated by reſt, decantation, filtration, or expreſſion. The action of theſe ſubſtances on colouring matters is examined, and the ſeveral changes which they are liable to ſuffer in different temperatures are obſerved. Animal liquors are carefully evaporated, and the different ſalts which they contain extracted from them unaltered.

By theſe methods of analyſis, modern chemiſts have made a number of important diſcoveries concerning animal ſubſtances. Scheele has found them to contain ſeveral acids different from thoſe which were before known. M. Berthollet has demonſtrated the exiſtence of phoſphoric acid, in a naked ſtate, in urine and ſweat; and has likewiſe found, in animal matters, a remarkable quantity of the azotic principle. This laſt diſcovery is one of the moſt important facts which the analyſis of animal matters has made known to us. The exiſtence of azote in theſe ſubſtances, eſpecially in their fibrous parts, accounts for the difference between animal and vegetable matters. This body is obtained in the ſtate of elaſtic fluidity, or in azotic gas, by treating the fleſh of the muſcles with nitric acid: even without the operation of any external heat, it is diſengaged in a pretty large proportion: it paſſes before the nitrous gas; and when the nitrous gas begins to be diſengaged, the operation ſhould be ſtopped, and the veſſels changed.

M. Berthollet explains by this diſcovery the formation of the ammoniac which animal ſubſtances afford, when treated with fire,—the production and diſengage-

ment

ment of this ſalt by putrefaction,—and the relation between theſe ſubſtances and vegetable matters that are liable to putrefaction, and afford ammoniac by diſtillation. It appears, in fact, that in both theſe inſtances, the ammoniac is formed by the combination of hydrogene with azote. I believe I cannot here do better than give, in M. Berthollet's own words, what he has ſaid concerning the nature of animal ſubſtances in general, in a Memoir read before the Faculty of Medicine, and inſerted in the *Journal de Phyſique*, vol. 28. page 272.

"Organized bodies are chiefly compoſed of two ſub-
"ſtances, which are diſtinguiſhed from each other by
"very eminent peculiar characteriſtics. Of theſe ſub-
"ſtances, one claſs affords acids, when decompoſed by
"the action of fire; the other *volatile alkali*: The one
"claſs forms *ardent ſpirit* by fermentation; the other
"immediately putrefies, ſtill affording *volatile alkali*:
"The one leaves, when calcined, a coal that burns ea-
"ſily; the other is reduced to a coal which burns with
"difficulty: The one, in ſhort, forms the greater part
"of vegetable, the other of animal ſubſtances; and
"hence they are diſtinguiſhed by theſe two different de-
"nominations.

"M. Bergman, by means of ſugar and the *nitrous acid*,
"produced an acid which he called the *ſaccharine acid*,
"poſſeſſing peculiar and remarkable properties. On ap-
"plying to animal ſubſtances this analyſis by *nitrous acid*,
"I found that they all afforded more or leſs *ſaccharine*
"*acid*, which was always accompanied with a peculiar
"oil. I obſerved that no ammoniacal ſalt was obtained,
"but a reſidue remained, which vegetable ſubſtances do

"not

" not afford. From theſe firſt experiments, I concluded, " in the *Memoirs of the Academy for the year* 1780, that " animal matters contained ſome ſubſtance analogous to " ſugar, in combination with an oil which I conſidered " as peculiar to animal matters. I learned farther from " my experiments, that *volatile alkali* did not exiſt in " animal ſubſtances, but was produced by ſome com- " bination, effected either by the action of heat, or by " the influence of putrefaction. And laſtly, The reſidue, " concerning which I did not explain my ſentiments in " that Memoir, contains an exceſs of phoſphoric acid, " combined with calcareous earth.

" I afterwards examined the action of metallic *calces* " and ſalts on animal ſubſtances, and proved, that the " action to which theſe owed their cauſticity was a con- " ſequence of the chemical affinities by which metallic " *calces* tended, with more or leſs force, to revivication; " the *calces* of ſilver and mercury, which are very eaſily " reduced, having an high degree of cauſticity, and " forming very cauſtic ſalts. It follows, on applying " the late diſcoveries of natural philoſophers to the theo- " ry which I have given, that it is the air, exiſting in a " combined ſtate in metallic *calces*, and without its prin- " ciple of elaſticity, which tends to unite with ſome " principle in animal ſubſtances; which principle ap- " pears to me to be the oil which they contain. But " the cauſticity of alkalis cannot be aſcribed to the " ſame cauſe: it muſt be owing to ſome other affini- " ty. In the Memoirs of the Academy for the year " 1782, I have proved that cauſtic alkali diſſolves " animal ſubſtances, without dividing their principles. " I have explained the properties of this combination,

and

" and afterwards employed it in uniting animal ſub-
" ſtances with the different metallic *calces.* Several
" combinations, not previouſly known to chemiſts, were
" produced: But cauſtic alkali, treated in the ſame
" way with vegetable ſubſtances, formed no combina-
" tion with them.

" Purſuing my reſearches, I have at length diſcovered
" the principles of *volatile alkali.* I have ſhown *volatile*
" *alkali* to be a combination of detonating *inflammable*
" *gas*, or, more accurately, of the inflammable gas of
" water with *phlogiſticated* or *mephitic* air, in ſuch pro-
" portions, that inflammable gas compoſes one ſixth of
" the weight, or two thirds of the bulk of *volatile alkali.*
" I next aſcertained in what manner *volatile alkali* may
" be produced by putrefaction, or the action of fire. All
" ſubſtances poſſeſſing the characteriſtics of animal ſub-
" ſtances contain *mephitis*, which may be ſeparated
" from them in abundance, by the operation of the
" *nitrous acid.* When thoſe ſubſtances are diſtilled, there-
" fore, their *mephitis* muſt of neceſſity either paſs into
" ſome new combination, or be found among their ae-
" riform products. But among theſe laſt it is never
" found; as I fully aſcertained by detonizing *inflammable*
" *gas*, obtained by this means, in M. Volta's eudiome-
" ter, and comparing it with inflammable gas obtained
" by diſtillation from charcoal and with that of vege-
" table ſubſtances; and, after the *inflammable gas*, there
" is none other but the *volatile alkali* among the pro-
" ducts obtained by diſtillation from animal ſubſtances,
" into the compoſition of which the mephitis can poſſi-
" bly be received. Conſequently, whenever *volatile al-*
" *kali* is formed, the *mephitis* of the animal ſubſtances

" combines with the *inflammable gas* ſeparated from the " oil, or more probably with that produced by the de- " compoſition of the water, whoſe vital air combines " at the ſame time with charcoal, to form *fixed air;* " in putrefaction, the *inflammable gas* combines with the " *mephitis;* whereas, in the ſpirituous fermentation, the " ſame gas combines with a vegetable oil and ſugar to " form *ſpirit of wine*, in which I have diſcovered and " ſeparated theſe ſubſtances by means of the *dephlogiſti-* " *cated marine acid.*

" From theſe ſeveral obſervations, it follows, that " animal ſubſtances are of a much more compound na- " ture than ſubſtances purely vegetable. They contain " a matter analogous to ſugar, a peculiar oil, phoſpho- " ric acid combined with calcareous earth, *mephitis*, and " very probably *fixed air.* It is the phoſphoric acid " which exiſts in the coal of animal ſubſtances, in com- " bination with a portion of real charcoal, oil, and earth, " that appears to me to occaſion the difference obſerved " between the coals of animal and thoſe of vegetable " ſubſtances."

Such is the accuracy and perſpicuity with which M. Berthollet explains the nature of animal ſubſtances in general. When theſe diſtinct facts and fair deductions are compared with the vague notions which before prevailed concerning the difference between animal and vegetable matters, the progreſs which chemiſtry has made within theſe few years, by means of the reſearches of Swediſh and French chemiſts, cannot but appear aſtoniſhing. There is the ſtrongeſt reaſon to hope, that farther experiments on animal matters, upon the ſame

plan which has been marked out and purſued by the moſt celebrated chemiſts, from Margraff and Rouelle to the preſent inſtant, will ſupply a great deal of valuable information concerning theſe ſubſtances; their formation, the alterations which they are liable to undergo, and their deſtruction; and particularly, may be of the moſt eſſential ſervice to the ſcience of Medicine. The truth of this aſſertion will be fully proved, by the account of the diſcoveries already made, and of their application, which we are to exhibit in the following chapters.

CHAP.

CHAP. II.

Of the Blood.

THE moſt important, the moſt compound, and the moſt impenetrable of the recrementitial humours, is the blood. We treat of it firſt, becauſe the greateſt phyſicians maintain it to be the ſource and centre of all the other animal fluids. Many phyſicians, eſpecially M. Bordeu, have conſidered it as a ſort of fluid fleſh, a compound of all the animal humours: an opinion, which, though highly probable, has not been yet fully demonſtrated.

The blood is a fluid of a beautiful red colour, of a fat, unctuous, and, as it were, a ſaponaceous conſiſtency; of a taſte ſomewhat ſaline, but almoſt inſipid; and contained in the heart, arteries, and veins. This fluid is differently modified by the different parts through which it flows: For inſtance, in the arteries and veins, in the breaſt, and the region of the liver, in the muſcles and the glands, &c. it is not the ſame. This fact has not ſufficiently engaged the attention of chemiſts.

In conſidering the blood as it exiſts through the whole animal kingdom, we obſerve, that in different animals it is ſingularly diverſified in colour, conſiſtency, ſmell, and eſpecially temperature. The laſt is the moſt important of all theſe properties, and ſeems to depend on the circulation and the reſpiration. The human blood, and that of quadrupeds and birds, is hotter than the medium which they inhabit; and, for this reaſon, theſe are called *hot-blooded animals*. The blood of fiſhes and reptiles, again, is nearly of the ſame temperature with the medium which they inhabit; and theſe are, for this reaſon, called *cold-blooded animals*. Other properties of this fluid, eſpecially its chemical qualities or characteriſtics, would probably be found, if we were acquainted with the blood of all animals, to be ſubject to the ſame variations.

The human blood, which more eſpecially engages our attention, is differently modified by the age, the ſex, the temperament, and the ſtate of the health, of each individual. In infants, the female ſex, and phlegmatic perſons, it is paler and thinner. In robuſt and healthy perſons, it is thick, of a deep red colour, almoſt black, and of a much more ſaline taſte than in the former.

Before proceeding to an analyſis of the blood, it is neceſſary that we get acquainted with its phyſical properties—its colour, heat, taſte, ſmell, and peculiar conſiſtency—of which we have already taken notice. By the microſcope we diſcover in it a great many globules, which, according to Lieuwenhoek and Boerhaave, when broken in circulating through the ſmaller paſſages, loſe their red colour, and become firſt yellow, and then white; ſo that, according to the phyſician of Leyden,

a red globule is an aſſemblage of other ſmaller white globules, and owes its colour to its aggregation. There is another ſingular property belonging to the blood. While hot and in motion, it continues fluid and red: When cooled and at reſt, it becomes a ſolid maſs, which, by degrees, ſeparates into two parts; the one red and ſupernatant, its colour dark, and its conſiſtency concrete, till ſuch time as it ſuffer an alteration;—this is called the *clot of the blood:* the other occupies the bottom of the veſſel, and is of a greeniſh yellow colour, and adheſive;—it is called the ſerum or lymph. This ſpontaneous coagulation and ſeparation of the two parts of the blood takes place in the laſt moments of an animal's life; and produces thoſe concrete matters which are found in the heart, and the larger veſſels of deceaſed animals, and have been miſtaken for polypi.

Blood, expoſed to a gentle and continued heat, paſſes into the ſtate of putrid fermentation. When diſtilled on a water-bath, it affords a phlegm of a faint ſmell, which is neither acid nor alkaline, but eaſily putrefies, in conſequence of its containing an animal ſubſtance diſſolved through it. Expoſed to a more intenſe heat, blood, as has been diſcovered by De Haen, gradually coagulates and becomes dry: it then loſes ſeven-eighths of its weight, and becomes capable of effervеſcence with acids. By conducting the fire properly, it may be hardened into a ſort of corneous ſubſtance. Deſiccated blood, expoſed to the open air, attracts from it ſome degree of moiſture, and, in the courſe of a few months, there is formed on it a ſaline efflorеſcence, which Rouelle has determined to be carbonate of ſoda. When diſtilled by naked fire, it affords a ſaline phlegm,—that is, a

phlegm holding in ſolution an ammoniacal ſalt, ſuperſaturated with ammoniac. The nature of the empyreumatic acid contained in this ammoniacal ſalt, which was firſt obſerved by Wieuſſens, and has given riſe to ſo many diſputes among phyſiologiſts, has never yet been ſufficiently examined. After this phlegm, a light oil paſſes, —then a ponderous coloured oil, and ammoniacal carbonate contaminated with a thick oil. There remains in the retort a ſpungy coal, very difficult to be incinerated, which is found to contain muriate of ſoda, carbonate of ſoda, oxide of iron, and a matter apparently earthy, which ſeems to be calcareous phoſphate.

Blood, when burnt in a crucible, affords ſeveral products, in the following order. 1. Water and a little ammoniac: 2. Oil and carbonate of ammoniac, which forms a yellowiſh vapour, thicker than the former: 3. Pruſſic acid, which is eaſily diſtinguiſhed by its fœtid ſmell of peach-flowers: 4. Phoſphoric acid, which is formed by the combuſtion of phoſphorus, and is not diſengaged till the blood be reduced to a coal: 5. Carbonate of ſoda, which is volatilized at an intenſe heat: 6. After this there remains in the crucible only a blackiſh, granulated, cryſtallized oxide of iron, mixed with calcareous phoſphate.

Blood combined with alkalis, without previous decompoſition, becomes more fluid by ſtanding. Acids inſtantaneouſly coagulate it, and alter its colour. By filtrating this ſubſtance, evaporating the liquor paſſed through the filter, drying it before a moderate fire, and lixiviating the matter that has been dried, neutral ſalts are obtained, conſiſting of ſoda, with the acid that was mixed with the blood. Alcohol coagulates blood.

If entire blood, mixed with a fourth part of its weight of water, be coagulated by heat, and if a part of the fluid that ſwims above the coagulated portion be evaporated, a ſubſtance of a brown yellow is obtained, which is eaſily diſtinguiſhed to be true bile. This diſcovery, which was made in 1790, confirms the opinion of the ancients, who conſidered bile as a conſtituent part of blood.

Experiments made on blood in its original ſtate, do not diſcover the nature of the ſubſtances of which it conſiſts. But the ſpontaneous decompoſition of blood, and the ſeparation of its two component parts, the clot and the ſerum, afford us an opportunity of acquiring that knowledge by examining each of theſe matters by itſelf. Till within theſe few years, the chemical analyſis of the blood was confined to what has been related in the foregoing pages; but Meſſrs Menghini, Rouelle the younger, and Bucquet, have examined this fluid in a very different manner. The two laſt of theſe chemiſts eſpecially have conducted their experiments on this matter in a way which ſhews to what perfection the analyſis of animal matters may be carried, by proceeding on their plan. The following account of the properties of the ſeveral ſubſtances which compoſe the blood, is derived from the diſcoveries of thoſe philoſophers, and from thoſe which I have made myſelf.

The ſerum is very far from being pure water; but a peculiar matter, highly worthy of examination, to which we give the name of the *albuminous fluid*. It is of a yellowiſh white colour, ſomewhat inclining to green; its taſte is ſaltiſh, but nearly inſipid; its conſiſtency unctuous and adheſive. When expoſed to the action of fire, it coagulates and becomes hard, long before it can be

heated to ebullition: it communicates a green tinge to ſyrup of violets. By diſtillation on a water-bath, it affords a phlegm of a mild inſipid taſte, which is neither acid nor alkaline, but ſpeedily putrefies. After loſing this phlegm, it is dry, hard, and tranſparent like horn: it is no longer ſoluble in water: by diſtillation in a retort, it affords an alkaline phlegm, a conſiderable quantity of ammoniacal carbonate, and a very fœtid thick oil. All theſe products, in general, have a peculiar fœtid ſmell. The coal of the ſerum, when diſtilled by naked fire, almoſt entirely fills the retort. It is ſo difficult to incinerate, that it muſt be kept burning for ſeveral hours, and expoſed to a great deal of freſh air, before it can be reduced to aſhes. The aſhes are of a blackiſh grey colour, and contain muriate and carbonate of ſoda, with calcareous phoſphate.

The ſerum, if expoſed for ſome time to an hot temperature, in an open veſſel, paſſes readily into a ſtate of putrefaction, and then affords a conſiderable quantity of ammoniacal carbonate, with an oil, the ſmell of which is inſufferably nauſeous. It putrefies ſo ſpeedily, that Bucquet could not diſcover whether it paſſed into an acid ſtate before becoming alkaline. This liquor combines with water in any proportion; and then it loſes its conſiſtency, its taſte, and its greeniſh colour. To promote the combination, the mixture needs to be ſhaken; becauſe the difference between the denſities of the two fluids obſtructs their union. The ſerum, when poured into boiling water, coagulates, almoſt wholly, inſtantaneouſly. A portion of this fluid forms, with the water, a ſort of opaque and milky white liquor; which, according to Bucquet, poſſeſſes all the characteriſtic properties

of milk; that is, is rarefied, and cauſed to mount up, like that fluid, by heat, and is coagulated by the ſame agents—by acids, and by alcohol.

The ſerum or albuminous fluid poſſeſſes the property of fixing and rendering ſolid by heat, two or three times its weight of water. When ſeven or eight parts of water are added to one of ſerum, then the albumen is not coagulated by heat. The cauſe of this ſingular property, of coagulating by heat, which the ſerum of the blood poſſeſſes, has hitherto eluded the reſearches of philoſophers. I imagine it to be owing to the combination of oxigene, aſſiſted by heat, as it is in all other ſubſtances; ſince a metallic oxide mixed with ſerum thickens it, whilſt itſelf paſſes into a metallic ſtate. Beſides, all the facts relative to the coagulation of the albuminous matter prove, that the more air this ſubſtance contains, the more of it it has abſorbed, and the more ſpeedily it coagulates by fire, ſo much the more ſolid does it become by this agent.

Alkalis render the ſerum more fluid by effecting a ſort of ſolution of it. Acids alter it in a different manner, increaſing its conſiſtency, and coagulating it. This mixture, filtrated, and evaporated after filtration, affords a neutral ſalt formed of ſoda and the acid employed: And this fact proves ſoda to exiſt in the ſerum in a naked ſtate, in full poſſeſſion of all its properties. The coagulum formed in this liquor by the addition of an acid, is very ſpeedily diſſolved in ammoniac, which is the genuine ſolvent of the albuminous part of the blood; but it does not diſſolve at all in pure water. Acids precipitate this matter in union with ammoniac. The coagulum, diſtilled by naked fire, affords the ſame products as

the

the ſerum deſiccated; and its carbonaceous reſidue contains a good deal of carbonate of ſoda;—a circumſtance which, in Bucquet's opinion, ſhews, that there exiſts a portion of this ſalt in a ſtate of intimate combination, in the ſerum, which the acid employed to coagulate it does not ſaturate.

The ſerum, inſpiſſated, affords azotic gas by the action of the nitric acid, with the help of a moderate heat. On increaſing the fire, there is a quantity of nitrous gas diſengaged from the mixture: the reſidue affords oxalic acid, and even a ſmall quantity of malic acid.

The formation and diſengagement of the Pruſſic acid by ſerum and the nitric acid, is a diſcovery which furniſhes a ſimpler and more œconomical proceſs than that of Scheele's, for obtaining this acid pure.

The ſerum does not decompoſe calcareous or aluminous neutral ſalts; but it acts with ſufficient energy in decompoſing metallic ſalts. It is liable to be coagulated by alcohol: this coagulum differs conſiderably from that formed in the ſerum by acids, chiefly in its ſolubility in water, as Bucquet has diſcovered. This liquid appears, therefore, from theſe reſearches, to be an animal mucilage, conſiſting of water, acidifiable oily baſes, muriate and carbonate of ſoda, with calcareous phoſphate: The roſe-coloured precipitate which I have obtained by pouring a portion of a nitric ſolution of mercury into the ſerum, appears to be owing to the latter of theſe principles. Although the liquid has ſcarce any colour, yet nitric acid, and ſtill more nitrate of mercury, produces, when poured into it, a roſe or light fleſh-colour, which I have had occaſion to obſerve in many other animal liquors. The moſt ſingular pro-

perty

perty of this mucilage,—a property highly worthy of engaging the attention of phyſicians,—is, its being liable to become concrete by the action of fire and acids. Scheele thought this phænomenon owing to the combination of heat. Its true cauſe has been taken notice of above.

The clot of the blood affords, by expoſure to the heat of a water-bath, an inſipid water; it becomes, at the ſame time, dry and brittle. It affords, in the retort, an alkaline phlegm, a thick oil, of a fœtid, empyreumatic ſmell, and a good deal of ammoniacal carbonate. The reſidue which it leaves, is a ſpongy coal, of a ſparkling metallic aſpect, difficult to incinerate, and affording, when treated with ſulphuric acid, ſulphate of ſoda and ſulphate of iron: there remains, after theſe operations, a mixture of calcareous phoſphate with carbonaceous matter. Expoſed to an hot atmoſphere, the clot putrefies readily enough. When waſhed with water, this fluid ſeparates it into two very diſtinct matters; the one it diſſolves, deriving from it a red colour. The ſolution, treated with different menſtrua, exhibits all the ſame characteriſtics with the ſerum, but is found to contain much more iron. The metal is ſeparated by incineration, and by waſhing the incinerated coal, in order to carry off the ſaline matters. The remaining part of the lixivium, after the ſaline matters are carried off, is in the ſtate of oxide of iron, of a brown colour, of conſiderable beauty. It is uſually ſubject to the attraction of the magnet. Blood is thought to owe its colour to this metal. A very conſiderable proportion of iron has been extracted from this fluid by Meſſrs Menghini, Rouelle, and Bucquet.

The

The clot, after being waſhed and cleared from all the red ſerum which it contains, is in the ſtate of a fibrous white matter; which it remains for us to examine.

The fibrous part of the blood is white and colourleſs, after being well waſhed: its taſte is inſipid. It affords, by diſtillation on a water-bath, an inſipid phlegm, without ſmell, and liable to putrefaction. Even the gentleſt heat hardens this fibrous matter in a ſingular manner. When expoſed ſuddenly to a ſtrong fire, it ſhrinks like parchment. By diſtillation in a retort, it affords an ammoniacal phlegm, a ponderous oil, which is thick and very fœtid, and a good deal of ammoniacal carbonate, contaminated with a portion of oil. The reſidual coal is not very bulky, but compact, ponderous, and eaſier incinerated than that of the ſerum. Its aſhes are very white: it contains no ſaline matter, as it muſt have loſt, by the waſhing, whatever it contained of that kind,—and no iron: it is a ſort of reſidue of an earthy appearance, and ſeemingly calcareous phoſphate.

The fibrous part of the blood putrefies very quickly, and with great facility. When expoſed to an hot moiſt atmoſphere, it ſwells, and affords a good deal of ammoniac. It is not ſoluble in water: when boiled in that fluid, it becomes hard, and acquires a grey colour. Alkalis do not diſſolve it; but even the weakeſt acids combine with it: The nitric acid diſengages from it a conſiderable quantity of azotic gas, as we are told by M. Berthollet: (I have likewiſe diſcovered, that the Pruſſic acid is formed, which is diſengaged in vapour;) and at length diſſolves it with effervescence, and the diſengagement

diſengagement of nitrous gas. When it ceaſes to emit nitrous gas, the reſidue is obſerved to contain oily and ſaline flakes, ſwimming in a yellowiſh liquor: This liquor affords, by evaporation, oxalic acid in cryſtals; and, at the ſame time, depoſites no inconſiderable quantity of flakes, compoſed of a peculiar oil, and calcareous phoſphate. It appears that hydrogene, carbone, and azote, which conſtitute the fibrous ſubſtance, are ſeparated in different proportions, to combine with the oxigene of the nitric acid, and thus form the Pruſſic and carbonic acids that are diſengaged in gas, and the oxalic and malic acids, that remain in ſolution, and are ſeparated only by cryſtallization.

The fibrous matter diſſolves alſo in the muriatic acid, which converts it into a ſort of green jelly. The acid of vinegar diſſolves it with the help of heat: Water, and eſpecially alkalis, precipitate this fibrous matter from acids. This animal matter is decompoſed in theſe combinations; and when ſeparated, by whatever means, from acids, no longer exhibits the ſame properties. Neutral ſalts, and other mineral matters, are incapable of acting upon it. It unites with the albuminous matter, eſpecially with that which is coloured, to form clot. This laſt ſubſtance, as well as the fibrous part, is totally ſoluble in acids; on account, no doubt, of the combination of this matter with the red ſerum. From this it appears, that the fibrous part differs greatly from the albuminous matter. It is more of an animal nature than that matter, being a ſort of animal gluten, bearing no ſmall reſemblance to that of farina, and poſſeſſing the remarkable property of becoming concrete by reſt and cooling. There is no doubt that this matter, which

has

has not been ſufficiently attended to by phyſiologiſts and pathologiſts, acts an important part in the animal œconomy. I have a conſiderable time ſince obſerved, that it is depoſited in the muſcles, and conſtitutes the fibrous baſe of thoſe organs, and that ſubſtance which is moſt eminently irritable. I have concluded this ſubſtance to merit more attention than it has yet obtained, and have conſidered it as capable of occaſioning, by its exceſs or deficiency, certain diſeaſes: And I have given my reaſons for entertaining ſuch opinions, in a Memoir which is inſerted among the Memoirs of the Royal Society of Medicine for the year 1783, &c. It appears that the peculiar acid which the blood affords by diſtillation, and which M. Chauffier has obtained from it by the action of alcohol, exiſts in the fibrous part of its ſubſtance. For this reaſon, I have propoſed to call it the *cruoric acid*, if it ſhould ever be determined to be a peculiar animal acid.

After all theſe ingenious diſcoveries concerning the nature of the blood, we are yet far from being ſufficiently acquainted with all its chemical properties. We are yet ignorant of the minute difference which ſubſiſts between the ſerum and the fibrous part. The blood has not yet been examined in all its various ſtates; particularly in different diſeaſes, in which that fluid ſuffers conſiderable alterations, ſuch as violent inflammations, the chloroſis, ſcurvy, &c. Phyſicians diſtinguiſh theſe alterations only by external appearances; and it is much to be wiſhed that accurate analyſes ſhould determine their nature, in ſuch a manner as to afford a better direction to the practitioner in the art of healing.

I have found the blood of a human fœtus to differ in

three

three remarkable particulars from that of an adult. It contained no fibrous ſubſtance, ſtrictly ſpeaking, but a ſort of gelatinous matter: it did not take a bright colour from the contact of air; nor did it afford any marks of phoſphoric acid.

Rouelle has examined the blood of various quadrupeds, the ox, the horſe, the calf, the ſheep, the hog, the aſs, and the goat. He obtained from them the ſame products which the human blood affords, but in different proportions.

CHAP.

CHAP. III.

Of the Milk.

THE milk is a recrementitial humour, deſigned by Nature for the nouriſhment of the young of animals in the firſt period of their exiſtence. It is of a dead white colour, a mild ſaccharine taſte, and a ſmell faintly aromatic. The female of the human ſpecies, female quadrupeds, and cetaceous animals of the ſame ſpecies, are the only animals that afford milk. No other animal is furniſhed with organs for the ſecretion of this humour. It was long thought, that the milk was immediately ſeparated, by glands in the breaſt, from the blood conveyed into them by the numerous arteries which meet there. But the principles of which milk is known to conſiſt, have not been hitherto proved to exiſt in the blood: and late diſcoveries in anatomy have ſhewn, that the breaſts are furniſhed with a great many lymphatic and abſorbent veſſels, diſpoſed in a fatty tiſſue; and

the

the liquor which theſe contain is perhaps one of the chief conſtituent principles of milk.

Milk is very different in different animals. In woman it is highly ſaccharine. Cows milk is mild, and its principles are intimately united. The milk of the goat and the aſs poſſeſſes peculiar virtues, and is often gently aſtringent. The properties of milk are liable to vary, as they commonly depend on the nature of the food with which animals are nouriſhed.

Cows milk, which we may take as an inſtance, as it is ſo eaſily procured, is a compound of three different ſubſtances; ſerum or whey, which is fluid and tranſparent; butter and cheeſe, which have more conſiſtency. Theſe three parts are ſo mixed and ſuſpended, as to form a ſort of animal emulſion.

Milk, diſtilled by the heat of a water-bath, affords an inſipid inodorous phlegm, ſuſceptible of putrefaction. Expoſed to a heat ſomewhat ſtronger, it coagulates like blood, as has been obſerved by Bucquet. When ſtirred and evaporated ſlowly, it forms a ſort of ſaccharine extract, known by the name of *franchipane*. This extract, diſſolved in water, forms Hoffman's whey. Diſtilled by naked fire, it affords acid, fluid oil, concrete oil, and ammoniacal carbonate. Its reſidual coal contains a little potaſh, muriate of potaſh, and calcareous phoſphate.

Milk, expoſed to an hot temperature, is liable to paſs into a ſtate of ſpirituous fermentation, in which it forms a ſort of wine; but a conſiderable quantity of it muſt be together, in order that this alteration may take place. The Tartars prepare a ſpirituous liquor from mare's milk. The milk becomes quickly acid, and then

coagulates. The cheeſe gathers into a maſs, leaving the whey ſeparate.

When heated pretty ſtrongly, milk experiences a ſingular thickening: it ſwells, forms a pellicle at its ſurface, which is renewed as faſt as it is removed, until the whole of the caſeous ſubſtance be ſeparated. Meſſrs Parmentier and Deyeux have aſcertained it to be the caſeous part which forms theſe pellicles.

Acids have inſtantaneouſly the ſame effect on milk. They coagulate it; this *coagulum* is again diſſolved by alkalis, eſpecially by ammoniac. Boerhaave aſſerts, that milk boiled with oil of tartar becomes firſt yellow, and takes afterwards a blood-red colour. He is even of opinion, that it is by ſome ſuch combination milk is converted in the human body into the ſtate of real blood. Neutral ſalts, ſugar, and gum, likewiſe coagulate milk, with the help of heat, as has been obſerved by Scheele.

To make whey, milk muſt be warmed with an addition of rennet, in the proportion of twelve or fifteen grains to the pint. This ſubſtance, being a mixture of milk ſoured in the ſtomachs of calves, with the gaſtric juice, is a fermenting ſubſtance which coagulates the caſeous part. After this coagulation is effected, the whey is ſtrained from the curds. The flowers of thiſtles, and artichokes, act on milk in the ſame way as rennet.

As to gallium, though it has got the name of milk-curdler, it does not poſſeſs that property, according to the obſervations of Meſſrs Deyeux and Parmentier. The external membrane of the ſtomachs of calves and birds, when dried and reduced to powder, produces the ſame effect on milk: a fact which proves,

that the coagulation of this liquor is owing to the dried gaſtric juice contained in the pores of that membrane.

The ſerum or whey, prepared in this way, is turbid; it may be clarified with white of eggs and tartar. When the ſerum or whey is wanted very pure, in order to be examined, no acidulous tartarite of potaſh ſhould be intermixed with it.

Whey has a mild taſte. When prepared from new milk, it contains a ſaccharine eſſential ſalt; but it ſoon acquires a ſour taſte, in conſequence of that fermentation which takes place in it. This emotion is produced by the alteration of a mucilaginous principle contained in milk; and it is the extrication of this acid from a latent ſtate which ſeparates the whey from the other principles of which milk conſiſts. It will therefore be proper to examine the nature of the acid which is formed in ſour milk, and conſtitutes fermented whey.

It is well known, that milk left to itſelf, at a temperature of ſeventy or eighty degrees, ſuffers, in the ſpace of a few days, a fermentation, which developes an acid, and ſeparates the butter and cheeſe. The acid which is formed by this fermentation, and acquires, in the ſpace of twelve or fifteen days, all the ſtrength of which it is capable, has been examined by Scheele: We call it the *lactic acid.* The following is the proceſs by which Scheele obtained this acid pure, after attempting ineffectually to ſeparate it from ſour milk by diſtillation. This operation having afforded him only a very ſmall portion of acid, he evaporated ſour whey to an eighth part, after filtering it, to ſeparate all the caſeous mat-

ter. The animal earth he precipitated by lime-water. He diluted it with three times its weight of water; and ſeparated the lime by oxalic acid. To aſcertain whether any oxalic acid remained in it, he aſſayed it with lime-water; and then evaporated the liquor to the conſiſtency of honey; and precipitated the ſugar of milk, and ſome other extraneous ſubſtances, by mixing with it alcohol, which eaſily diſſolves the lactic acid. Laſtly, He diſtilled this ſolution; and after the alcohol was thus volatilized, the lactic acid remained pure in the retort. Scheele aſcribes to this acid the following properties.

Evaporated even to a very thick conſiſtency, it affords no cryſtals; it attracts moiſture from the atmoſphere. By diſtillation, it affords an empyreumatic acid, reſembling the pyro-tartareous acid, a little oil, and a mixture of carbonic acid gas, with carbonated hydrogenous gas.

In union with the three alkalis, with barytes, or with lime, the lactic acid forms deliqueſcent ſalts. In combination with magneſia, it forms cryſtals; but theſe, too, attract moiſture from the atmoſphere. Moſt of theſe ſalts of milk, or alkaline and earthy lactates, are ſoluble in alcohol. The acid of milk does not act, in any way, on cobalt, biſmuth, antimony, mercury, ſilver, or gold, even though aſſiſted by a boiling heat. It diſſolves zinc and iron, producing from them hydrogenous gas: the former of theſe ſalts, lactate of zinc, cryſtallizes; the other, lactate of iron, forms a deliqueſcent brown maſs.

The lactic acid oxidates and diſſolves lead and copper. The lactic ſolution of lead depoſites a little ſulphate of lead;

lead; from which it appears, that this animal acid contains a ſmall portion of ſulphuric acid. Laſtly, It decompoſes acetite of potaſh: This laſt property, with the reſt here mentioned as belonging to it, ſhew the lactic acid to be different in its nature from vinegar. To theſe particulars, Scheele adds, that real vinegar may be obtained from milk, by mixing ſix ſpoonfuls of alcohol with three pints of milk, and leaving the mixture to ferment in a well-ſtopped veſſel: the gas diſengaged by the fermentation of the mixture, muſt be, from time to time, ſuffered to eſcape: at the end of a month, the milk is found changed into good vinegar: it may be then ſtrained through a cloth, and put up in bottles. The celebrated Swediſh chemiſt adds farther, that milk in a bottle, the neck of which enters a veſſel filled with the ſame liquor, undergoes, if expoſed in this condition to a heat ſomewhat ſuperior to the ordinary heat of ſummer, a fermentation which occaſions the diſengagement of a large quantity of elaſtic fluid: This fluid diſplaces the milk, ſo as nearly to empty the bottle in the ſpace of two days: The acid produced by this fermentation, which takes place without the contact of air, ſeems to owe its oxigene, the acidifying baſe of air, to the decompoſition of water.

The whey of ſweet milk, ſeparated by rennet, without ſouring, holds in ſolution a certain quantity of alkaline ſubſtance, known by the name of ſalt or ſugar of milk. Although Kempfer aſſerts, that the Brachmans have a proceſs for preparing this ſalt, it appears that Fabricius, Bartholet or Bartholdi, an Italian phyſician, firſt mentioned it to the world, in the year 1619. Etmuller Teſti, Werloſchnigg, Walliſnieri, Fickius, and Cartheuſer,

have ſucceſſively written concerning it, and deſcribed proceſſes for its preparation. Meſſrs Vulgamoz and Lichtenſtein have given very particular accounts of the art of extracting this ſaline ſubſtance, which is prepared in the great way in different places in Switzerland. They there evaporate whey, obtained from milk by ſkimming and coagulating it with rennet, till it be reduced to the conſiſtency of honey: This ſubſtance, put into moulds, and dried before the ſun, forms ſugar of milk in tablets: theſe are diſſolved in water, clarified with white of eggs, and evaporated to the conſiſtency of a ſyrup; and then the liquor is cryſtallized in the cold: white cryſtals are formed in it, in rhomboidal parallelipipeds; the mother-water depoſites yellow and brown cryſtals, which are purified by ſucceſſive ſolutions. M. Lichtenſtein has examined and analyſed the different ſugars of milk that are ſold in Switzerland at different prices; and has particularly diſtinguiſhed, 1. *The ſweet ſugar of milk*, which is extracted from ſweet purified whey: 2. *The aceſcent ſugar of milk*, obtained from ſour whey: 3. Sugar of milk, *rendered impure by a mixture of fat particles*, which, according to him, ſeparates in the firſt cryſtallization: 4. Sugar of milk, *mixed with oil and common ſalt*, which is laſt cryſtallized: 5. Sugar of milk, *mixed with fat particles, common ſalt, and ſal ammoniac*; it is glutinous and moiſt; treated with fixed alkali, it affords ammoniac: 6. Laſtly, Sugar of milk, mixed with all the above-mentioned ſubſtances, *and likewiſe with extractive and caſeous matter*; this laſt ſugar is of the conſiſtency of honey; it is liable to turn rancid, and is acrid and diſagreeable.

Pure

Pure ſugar of milk taſtes, in a faint degree, like ſugar, inſipid, and ſomewhat earthy. By repeated ſolutions, there is always ſo much of it loſt. It diſſolves in three or four parts of hot water: It affords, by diſtillation, the ſame products as ſugar, according to Meſſrs Rouelle, Vulgamoz, and Scheele. The firſt of theſe chemiſts obtained, by burning, a pound of this ſalt, from 24 to 30 grains of aſhes; of which three fourths were muriate of potaſh, and the remaining fourth part carbonate of potaſh. On a burning coal, ſugar of milk melts, ſwells, gives out a ſmell of caramel, and burns like ſugar. Theſe properties afforded reaſon for thinking, that this ſalt would, like ſugar, afford oxalic acid, if treated with nitric acid. Scheele's experiments have confirmed this conjecture: But he obſerves, that a much more conſiderable proportion of ſpirit of nitre is neceſſary for this purpoſe, than to produce oxalic acid from common ſugar; and that 4 ounces of ſugar of milk afford 5 drams of oxalic acid: And he has farther diſcovered, that the reſidue of ſugar of milk that has been treated with nitric acid, when diluted in water, and filtrated, in order to the evaporation and cryſtallization of the oxalic acid, leaves on the filter a white powder, which he found to poſſeſs the characteriſtics of a peculiar acid, different from the former. This we denominate the *ſaccho-lactic acid.* The following are its properties, as obſerved by Scheele:—

This acid is in the form of a white granulated powder. Two drachms of this ſalt, in a ſtate of conſiderable purity, on being expoſed to heat in a glaſs-retort, melted, ſwelled, and turned black. There was ſublimated from this matter, a brown ſalt, the ſmell of which

was a compound of the ſmell of benzoin with that of amber, and which weighed 35 grains. This ſublimate was acid, ſoluble in alcohol, but not ſo eaſily as in water, and burned on the coals. In the receiver, there was found a brown liquor, which poſſeſſed none of the characteriſtics of an oily ſubſtance. In the retort, there remained 11 grains of coaly matter. Both carbonic acid and hydrogenous gas were diſengaged during the diſtillation. The ſaccho-lactic acid is ſcarce ſoluble in water; for an ounce of boiling water diſſolves only ſix grains of it; and even of that quantity, a fourth part is precipitated by cooling.—M. de Morveau ſays, that this acid effervеſces with an hot ſolution of carbonate of potaſh. Saccho-lacte of potaſh, cryſtallized by cooling, was diſſolved in eight times its weight of hot water, and cryſtallized anew by the cooling of the liquor. Saccho-lacte of ſoda is ſuſceptible of cryſtallization, and only five parts of water are requiſite to diſſolve it. This acid likewiſe combines with ammoniac; but heat deprives the neutral ſalt thus formed of its volatile baſe. With barytes, alüminous earth, magneſia, and lime, the ſaccho-lactic acid forms ſalts which are almoſt inſoluble. It acts with little energy on metals; with their oxides it forms neutral ſalts, which are ſcarce ſoluble. It precipitates nitrates of mercury, lead, and ſilver; as alſo muriate of lead.

When Scheele firſt made this diſcovery, he thought, that the white powder depoſited by the oxalic acid, obtained from ſugar of milk by the nitric acid, was nothing but calcareous oxalate, the formation of which was owing to lime which might poſſibly be contained in this animal ſalt; but he was ſoon undeceived, when, on

pouring

pouring a ſmall portion of pure oxalic acid into a ſolution of ſugar of milk, he found the mixture to afford no precipitate. Yet M. Hermſtadt, who, in Crell's Journal, has given two Memoirs on ſugar of milk, in the ſecond of which he enters into a particular examination of this earthy acid; thinks, notwithſtanding Scheele's experiments, that it muſt be a compound of oxalic acid and lime with a fat matter. But M. de Morveau, examining, with his uſual accuracy, the experiments of this chemiſt, and comparing them with thoſe of Scheele, has ſhewn, in the new *Dictionnaire Encyclopædique*, that M. Hermſtadt has not accompliſhed his object, and that even the reſults of his experiments rather confirm than contradict the diſcoveries of the Swediſh chemiſt. M. de Morveau has himſelf made ſeveral ingenious experiments, which concur to eſtabliſh the ſame fact.—To theſe particulars we may add, that the oxalic and the ſaccho-lactic acids do not exiſt ready-formed in ſugar of milk; and that this ſalt contains only the baſes which attract oxigene, or the acidifying principle from the nitric acid. We may farther obſerve, that new experiments may one day, perhaps, ſhew the ſaccho-lactic acid to be nothing but a modification of ſome other vegetable acid; for every thing tends to prove, that the principles of whey have belonged originally to the vegetables with which the animals that afford it are nouriſhed.

Baron Haller repreſents ſugar of milk as exiſting in the following proportions, in the milk of the following animals:

Four ounces of ſheep's milk afford from 35 to 37 grains of ſugar of milk:

The

The ſame quantity of goat's milk - from 47 to 49
——————— of cow's milk - from 53 to 54
——————— of woman's milk from 58 to 67
——————— of mare's milk - from 69 to 70
——————— of aſs's milk - from 80 to 82

Rouelle has obſerved, that after the ſugar of milk is extracted from the whey of cow's milk, it cools into a ſort of jelly; and accordingly believes it to contain gelatinous matter.

The cheeſe, or caſeous part of milk, is formed into a maſs, and ſeparated from the other parts of the liquid, by the action of fire, by the acid fermentation to which milk is liable, and by the intermixture of acids. This matter, when well waſhed, is white and ſolid, like the albumen of the blood, when coagulated by heat. A gentle heat hardens it. By diſtillation on a water-bath, it affords an inſipid phlegm, ſubject to putrefaction.

Dried cheeſe affords, by diſtillation in a retort, an alkaline phlegm, a ponderous oil, and a conſiderable proportion of ammoniacal carbonate. Its coaly reſidue is denſe, very difficult to incinerate, and incapable of affording fixed alkali. When treated with nitric acid, it is found to contain lime and phoſphoric acid.

Cheeſe putrefies in a hot temperature: It ſwells, diffuſes a noiſome ſmell, becomes half-fluid, and, in conſequence of the diſengagement of a ſtrong-ſmelling and highly mephitic gas, which with difficulty eſcapes from this viſcid matter, is covered over with froth.

Cheeſe is not ſoluble in cold water; and hot water hardens it. Scheele has obſerved, that when it has been precipitated

precipitated by an acid, boiling water becomes capable of diſſolving a part of it.

The alkalis diſſolve it: ammoniac eſpecially, when a few drops of it are poured into milk coagulated by an acid, cauſes the *coagulum* in a ſhort time to diſappear.

Concentrated acids alſo diſſolve cheeſe. The nitric acid diſengages azotic gas from it. The vegetable acids do not diſſolve it in any ſenſible degree. The ſolution of cheeſe in the mineral acids is precipitated by alkalis; of which, however, too great a quantity diſſolves the precipitate again.

The neutral ſalts, eſpecially muriate of ſoda, retard the putrefaction of this ſubſtance. Alcohol coagulates it.

From theſe particulars it appears, that cheeſe is a ſubſtance, like the albumen of the blood.

Butter is in part ſeparated from milk by reſt, and collected on the ſurface. But being, in this ſtate, mixed with a good deal of ſerum and caſeous matter, it is ſeparated from theſe matters by rapid agitation. This is the art of making or churning butter.

In the ſeparation of the cream, and in the formation of the butter, a phænomenon takes place, which has not hitherto met with that attention from philoſophers which it deſerves. The contact of air, and the abſorption of oxigene, are neceſſary to the production of butter, and to its being obtained in a ſolid form. It is not completely formed in the milk. In proportion as it collects on the ſurface, it abſorbs oxigene from the atmoſphere, and ſeparates itſelf from the other principles of the milk in conſequence of its ſolidity, and from its now aſſuming the nature of a concrete oil. Hence it cannot

be

be diſengaged by agitation till after a certain period; and till ſuch time as it has abſorbed the requiſite quantity of oxigene, it does not conſtitute a maſs, nor does it take a conſiſtence by the ſtrongeſt agitation.

The ſerum which ſwims over churned butter, ſtill retains a portion of this oily ſubſtance; it is yellow, ſour, and fat, and is called *butter-milk*. What is called *cream*, is a mixture of cheeſe and butter, ſkimmed off milk. It is much more difficult to digeſt than pure milk. A conſiderable agitation will reduce this ſubſtance into froth: in this ſtate, it is called *whipped cream*.

Pure butter is ſoft and concrete, of a golden yellow colour, ſometimes higher, ſometimes lighter, and of an agreeable ſweet taſte. By a gentle heat, it melts; and by cooling, becomes ſolid. When diſtilled on a water-bath, it affords an almoſt inſipid phlegm. In the retort, it affords, an acid, of a very ſtrong pungent ſmell; at firſt, a fluid oil; and afterwards, a concrete coloured oil, of the ſame pungent ſmell with the acid. When theſe products are rectified, the oil is rendered as fluid and volatile as eſſential oils. The reſidual coal is but very ſcanty. The acid which butter affords by diſtillation appears to be of the ſame nature with that which is extracted from greaſe; of which we will hereafter ſpeak, under the name of the *ſebacic acid*. It may alſo be extracted in neutral ſalts, by the application of lime, potaſh, or ſoda.

Butter, in a hot temperature, eaſily becomes acid and rancid. Its acid is then diſengaged from a latent ſtate, and is found to have a diſagreeable taſte. Water and alcohol, by diſſolving the acid, reduce the butter nearly

to

to its former ſtate. Fixed alkali diſſolves butter, and forms a real ſoap with it.

From this detail of particulars, it appears, that butter is an oily ſubſtance, of the ſame nature with concrete vegetable fixed oils.

Freſh butter is ſweet, cooling, and relaxing; but it eaſily becomes ſour, and agrees but with few ſtomachs. Brown butter, the acid of which is developed, is one of the moſt unwholſome articles of food, and the moſt difficult to digeſt, that can be made uſe of.

Milk is an aliment both agreeable and uſeful in a great many caſes. It is even one of the moſt valuable medicines that can be preſcribed. In diſeaſes affecting the ſkin or joints, ſuch as the ring-worm, the gout, &c. it ſweetens the acrid humours. It even heals up ſome ulcers that are not of a very malignant ſort. It may be impregnated with the aromatic parts of plants: it is then an excellent medicine for the phthiſis pulmonaris. All ſtomachs are not fit for digeſting milk: It is generally troubleſome to people who are liable to the heart-burn, from too much acidity in the primary paſſages: It ſhould be almoſt always adminiſtered with great caution. Milk rendered medicinal, by feeding the animal which affords it on certain ſubſtances for that purpoſe, is often uſed with ſucceſs.

The milk of different animals poſſeſſes different virtues. Woman's milk is ſweet, and highly ſaccharine, and produces very happy effects in the caſe of a maraſmus. Aſs's milk is ſucceſsfully uſed for the phthiſis pulmonaris, and the gout; it commonly relaxes. Mare's milk is nearly of the ſame quality with that of the aſs. Goat's milk is ſerous and gently aſtringent. Cow's milk is thicker

thicker, richer, more nouriſhing: it is likewiſe more difficult to digeſt; and it is frequently neceſſary to dilute it with water, or ſome aromatic infuſion, eſpecially if it be found difficult to digeſt, or if it occaſion looſeneſs or vomiting.

Milk is likewiſe employed externally as emollient and relaxing. It relieves pains, it ripens abſceſſes, and accelerates their ſuppuration. It is applied warm, incloſed in a bladder, to the parts affected.

THE END OF VOLUME THIRD.

00033515

Digitized with financial assistance from the
Government of Maharashtra
on 25 June, 2016